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Building the Future

Recognising and nurturing talent in engineering

A report for the Stephen Lawrence Charitable Trust

Annie Haight

Westminster Institute of Education
Oxford Brookes University

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Project group and research team

Project steering group

Hilary Lowe
Marlene Morrison
Kathryn Ecclestone
Annie Haight

For the Stephen Lawrence Charitable Trust
Ian Gittens
Christine Jude

Researchers

Annie Haight
Joe Harkin

Report author

Annie Haight

with contributions from:
Joe Harkin
Hilary Lowe
Susannah Wright

Westminster Institute of Education
Oxford Brookes University

May 2010

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Executive summary

This study investigates the issues of recognising and nurturing young people's talent in engineering in a disadvantaged borough of London. It reviews research literature and key policy documents on:

- the role of education in promoting social mobility
- gifted and talented education
- engineering education.

The study's empirical research draws on the experiences of learners and teachers of engineering on a Specialist Diploma course and vocational programmes in a Further Education college, and in an Engineering Access programme jointly taught by the college and a London university. The research comprised a baseline survey of secondary and FE students in the college, and case study interviews with learners and teachers of secondary, further education and university Access courses.

With a sample size of nearly 100, the baseline survey allows a relatively confident degree of generalisation, at least among learners in similar areas of urban disadvantage. The case study interviews were conducted with much smaller samples, so generalisability is limited. It is likely that the teacher responses are representative of professional views to some degree, again, at least in relation to institutions catering for a similar demographic. The findings from the student interviews are specific to the individual participants, yet the congruence between the survey and interview results in several key areas indicates that they might be taken as representative to some degree. In any case the richness of detail in their individual responses adds depth and immediacy to a number of the issues emerging from the overall research picture.

Key points from the review of literature and policy

The Labour administration of 1997 to 2010 pursued a policy of using education to foster social justice and mobility among socio-economically disadvantaged groups. The Gifted and Talented agenda and widening participation initiatives were designed to promote these aims. In the case of the former, however, additional educational goals and emphases, distributed in a more widespread and 'socially-blind' way, meant that the aims of redressing educational disadvantage for talented learners were not always realised.

At the same time, a focus on 'under-served populations,' including minority ethnic and socially disadvantaged learners, became more important in the international field of gifted and talented education. This was part of a wider trend from 'reductionist' models of ability premised on cognitive ability tests, to more 'emergentist' models that focus on developmental, contextual, dispositional and behavioural aspects such as motivation, 'mindset,' effort and practice.

The area of vocational talent is relatively under-explored, although one model (Clow and Haight 2007) hypothesises that this type of ability depends on a wider and more rounded set of capabilities than more traditional academic ability. This hypothesis is tested in this study, and appears to be substantiated by its findings. There are approaches to teaching gifted and talented learners that take this wider set of capacities into account (Taylor 1968, Renzulli 2003) and have the potential to work well with talented vocational learners, who respond better to an 'authentic pedagogy' (Newman and Wehlage 1999) focused on applied learning in real-world situations.

A number of policy documents concerned with social mobility, skills development and the status and future of engineering emphasise the crucial role further education plays in providing educational routes for vocational learners, including those who wish to develop their skills to degree and professional levels. There are still notably low levels of black and minority ethnic (BME) and female engineers and engineering students. For engineering students in all phases, perceptions in the status of the profession and gaps in mathematical proficiency are key issues.

Key points from the baseline survey

The baseline survey revealed a strong preference among Specialist Diploma and post-16 vocational students for the practical, hands-on aspects of engineering. This was confirmed in the case-study interviews, where students reported, and teachers confirmed, that for both talented and mainstream students, learning is enhanced by synergies between the theoretical and practical aspects of their courses. Among the surveyed students, writing, mathematics and theory were cited as the weakest and least favourite aspects of their learning.

The survey also discovered high levels of intrinsic motivation for studying engineering, with 90% of respondents giving reasons such as liking hands-on work, or liking to fix things, as their primary reason for studying the subject. This finding was also strongly substantiated by the interviews with both learners and teachers. The important role of family support and of teachers' help was also highlighted in the survey. Some students expressed a self-reliant attitude to learning, with nearly a quarter indicating the prime importance of their own efforts in getting to grips with difficult content.

Perhaps the most striking finding was the high level of university aspiration among apprentices. Forty-five percent of apprentices in the survey expressed a desire to attend university, which compares with the extremely low percentages (0 to 0.2%) found in a Learning and Skills Council study from 2007-08. Tentative explanations for this might include the fact that all the apprentices surveyed in the present study were already in further education (not the case in the LSC study), and the influence and example of the further education lecturers, all of whom had worked as engineers, and one of whom had been an apprentice himself before undertaking higher education.

Ten percent of the survey respondents were female (all teenagers). The proportion indicating a preference to attend university (just over half) was in line with the overall responses for their age group in the sample. The ethnic group with the highest aspirations to attend university were students self-identifying as Black/Black British: African. This was followed, in descending order, by students who identified themselves as Other White, Black/Black British:Caribbean, and White British.

Key findings from the interviews

Semi-structured case-study interviews with learners were carried out with ten students:

- 4 secondary students studying on the Engineering Specialist Diploma
- 3 FE students undertaking Level 3 vocational engineering courses
- 3 university students doing university Access degrees in engineering.

Teachers' perspectives were ascertained through interviews with six teachers:

- 1 secondary teacher on the Engineering Specialist Diploma
- 3 FE engineering lecturers
- 2 university lecturers teaching on the Access course in engineering.

In order to structure discussions about what talent looks like in engineering students, Clow and Haight's KAMIS model of vocational talent (2007) was presented for critique to the secondary teacher and further education lecturers, and used to inform the interview questions with learners. The model posits five key areas of capability that combine in vocational talent:

- **K**nowledge and skills
- **A**utonomy
- sensori-**M**otor abilities
- **I**ntrinsic drive
- **S**ocio-affective skills.

Responses from both teachers and learners indicate that the key facet of this model is intrinsic drive, often expressed as 'an added keenness' and passion for the subject. These characteristics were evidenced in the learners, and confirmed by teachers, with levels of motivation, independence and resilience increasing through the age groups and educational levels.

Both learners and teachers confirmed the survey findings regarding the centrality of learning through the practical, hands-on aspects of engineering and the difficulties with mathematics and theory. Teaching that maximised the synergies between practice and theory appeared to be highly developed and greatly valued by learners in the Specialist Diploma and vocational courses in the FE college.

Both teachers and learners in all phases found problem-based, collaborative learning to be the most effective way for students to master and apply challenging concepts, and reported wanting to use more of this. The FE and HE teachers regretted the absence of strong links with employers in the sector. The FE teachers described with feeling the difficulties in organising work placements for their students.

Most, but not all, of the students interviewed had high levels of family support. A few did not. The Access students without such support showed considerable levels of independence and determination in pursuing their studies, and found help from their teachers and fellow students. A number of the students had family or friends in engineering. The students reiterated the high level of appreciation for teachers shown in the survey. As one secondary student said, 'The teachers teach you in ways that you understand.' Supportive personal relationships with teachers were also valued, especially among the FE vocational learners: 'They give you an encouraging word…If you [show them] your work they smile and say, "That's really nice, man."'

The teachers reported that constraining factors on students' success included financial difficulties, family issues, peer pressure, bullying, and 'gang worries'. Inflexible employers, shortages of child-care, and inconsistencies in the application of Benefits rules (such as those for Job Seeker's Allowance) militate against retaining some talented learners.

The Specialist Diploma in Engineering appeared to be popular and working effectively in the partnership investigated in this study. The secondary and FE teachers had forged good communications and a good working relationship. (This was felt by the secondary teacher to be atypical among similar partnerships.) The collaboration between the college and secondary school allowed talented secondary students to be promoted into Level 2 vocational classes, an interesting development in terms of breaking down the ‘academic–vocational divide’. The college benefited from a £1 million refurbishment of teaching premises. However, there appeared to be issues of equity between the secondary school and the FE college in the distribution of other supporting facilities such as an e-mentoring scheme and enrichment events, with the college able to access fewer of these.

The university Access course was more problematical. Both students and lecturers would have liked more ‘hands on,’ problem-based and collaborative learning opportunities. The university lecturers felt that it was too hurried and crammed with content at the expense of laying a solid foundation of basic principles including mathematics. They felt that the promise of adequate preparation for ‘an intense BEng course’ in one year gave Access students ‘false hopes.’ From their end, the FE lecturers would have liked to increase the amount of mathematics on the course. They also reported that students arrive at the college ill-prepared to begin post-16 work at the appropriate level, with weaknesses in numeracy and literacy needing to be remediated before students can access core engineering content.

Key conclusions and recommendations

Engineering, because of its wide remit, has the potential to be a vehicle for social mobility. Vocational courses in engineering offer talented students from disadvantaged or non-traditional backgrounds, and those previously disaffected by schooling, the opportunity to join the sector and to progress to degree and professional levels if they wish.

The Specialist Diploma in Engineering and the vocational courses in engineering can be taught, as in the case of the case study FE college, in ways that engage and extend learners’ appetite for practical, hands-on, problem-based learning. Teachers and further education lecturers with expert professional knowledge and a history of employment in the sector play a crucial role in delivering this type of learning and modelling the role of ‘engineer’ to their students.

There are a number of barriers to success for vocational routes in engineering, including students’ gaps in basic numeracy and literacy on entry, and a lack of employer contact and engagement. Disadvantaged learners often bear the added difficulties of challenging financial and personal circumstances, fear of debt, and the vagaries of the benefits system.

The transition from post-16 to university education is especially important, and vocational learners tend to struggle with difficulties in the mathematical and theoretical foundations for degree-level learning. This situation is not helped if Access courses are not long enough to provide students with secure footings in essential principles.

Recommendations from the study include:

- the continuation of efforts to provide high-quality vocational routes into degree-level engineering
- the retention of the Specialist Diploma in Engineering, drawing on and cascading lessons in good practice from effective providers
- investigation into the establishment of Apprenticeship Scholarships to higher education
- a review of university Access courses, with a view to strengthening their capacity to provide robust foundations in fundamental principles

- the continuation and co-ordination of efforts to strengthen mathematics education
- a review of benefits system policy and practice with regard to committed learners on higher-level vocational and university Access courses
- collaboration between voluntary, professional and public sector organisations to engage learners from the primary to post-16 phases in the excitement and intrigue of STEM activities, and to share the lessons in effective practice from these efforts.

Introduction

Background

This report was commissioned by the Stephen Lawrence Charitable Trust to inform its Youth, Creativity and Design programme and contribute to its ongoing aim of promoting social justice through nurturing the talents, life chances and productive contributions of young people in the domain of urban design. The study investigates the issues of identifying and fostering young people's talent in a representative technical subject from secondary to university Access level. It draws on the experiences of learners and teachers in engineering in a Specialist Diploma course and vocational programmes in a Further Education college in London, and in an Engineering Access programme jointly taught by the college and a London university.

Engineering was identified by the Trust as an appropriate technical and vocational subject to investigate in this context for several reasons. As a vocational and technical subject, it has direct and indirect links with roles and occupations in the built environment, for example structural engineering and civil engineering. Engineering is also a flexible and widely-defined domain. The role of 'engineer' is something of a 'portmanteau' occupation, encompassing a wide range of activities and jobs from craft to professional level, in a number of areas including structural, civil, chemical, aerospace, sound and software engineering. In this sense it has significant potential as a route for social mobility. A passion for motorcycles, for example, if properly nurtured, could lead a talented individual, via study and development, to productive work as a mechanic, to possible self-employment (and the employment of others), or to university study and professional status.

Engineering, as one of the STEM subjects (Science, Technology, Engineering and Mathematics) is regarded as of key importance to national productivity and competitiveness, and has a long and distinguished history of contributing to British innovation and economic vibrancy. Young people are specifically encouraged by the government to enter engineering, as evidenced by the creation of additional, dedicated university places in STEM subjects. The new Specialist Diploma in Engineering represents an effort to encourage secondary-school students to pursue this field, as well as an effort to dismantle the traditional dichotomy in British education between 'academic' and 'vocational' subjects and pedagogy.

In sum, engineering represents an economically and technologically vital area in terms of its contribution to employment and innovation. It is an integral element of urban design and represents a route to social mobility with many different pathways for productive engagement with the world of work, and for advancement. With a new award that encourages the integration of applied and academic learning, engineering may become increasingly attractive and relevant to young people who may not have been well served by education in the past.

The fieldwork for this study, which comprised a baseline survey and follow-up case study interviews with secondary, FE and HE students and teachers, was conducted in a London further education college and a London university. The further education college is located in one of the five most deprived boroughs of London. The borough is among the twenty most deprived areas in England, according to the 2007 Index of Multiple Deprivation. Fifty percent of its population was classed as White British and nearly 40% as belonging to ethnic minority groups, according to the 2001 census. Unemployment in the borough is higher than the London or national averages. Over 130 languages are spoken in the area, according to pupil survey data from 2008. The college is popular with its students and has forged an effective partnership with a local secondary school in the teaching of the Specialist Diploma in Engineering. It has a solid track record in preparing its students for occupations in engineering. A number of its more academically-minded students progress from its HE Access course to engineering degree programmes in London and other parts of England and the United Kingdom. The university is a post-1992 institution with a tradition of outreach to students from non-traditional backgrounds and a strong department of engineering.

Research focus and aims

The primary focus of the study was the identification, attitudes, teaching and support of able vocational-technical learners, considered from the viewpoints of both learners and their teachers. For the purposes of the research, the terms ‘able’, ‘gifted’ and ‘talented’ are used interchangeably, with the term ‘talented’ being preferred. These terms are defined as high potential or performance relative to the normal intake of the school or college in question (rather than, for example, in terms of performance on standardised cognitive ability tests or the like). In other words, the definition is ‘norm-referenced’ rather than ‘criteria-referenced’. This is in line with current educational policy and guidance on ‘gifted and talented’ learners in the UK.

Moreover, the researchers intentionally took a non-directive approach to this issue, inviting the engineering teachers to nominate the talented learners who were interviewed. The teachers’ understandings of ability in their subject area and educational context formed a key aspect of the research focus and were discussed at length in the interview conversations. In other words, a ‘grounded’, contextualised, empirical and subject-specific view of ability was sought. Teachers’ implicit theories were both allowed to shape the research (through the nomination of students for interview) and analysed in light of the literature in the field.

The rationale for this is that both vocational learners and learners in socially deprived areas are likely to exhibit or discover their talents in different ways, and at different rates, than learners in more traditionally academic areas, or from more educationally privileged backgrounds. Teachers’ experience of this is a vitally important source of knowledge in these relatively under-researched areas. In keeping with this principle, the university Access students were identified by their HE lecturers on the basis of showing notable potential and of having come to the course via vocational education.

The baseline survey was conducted with secondary and FE students from the entire ability range and varying in age from 14 to over 40. The survey, administered via web-based survey software, aimed to establish a picture of how engineering students in the secondary and post-compulsory vocational phases prefer to learn, what they like and find helpful in their learning, and what their aspirations are for the future. This information is valuable in its own right, and also served as contextual background for the interviews. The survey software allowed the data to be filtered and searched on a number of parameters, including age, gender, ethnicity, and type and level of course.

The case study interviews sought the views of a sample of secondary, FE and HE students nominated as talented by their teachers. The interviews focused on students’ learning preferences and motivation, attitudes toward their subject, and experiences of support and constraints. Interviews with the teachers focused on their conceptions of what talent in engineering looks like, how they recognise and develop it, and their perceptions of key constraints and sources of support. The secondary and FE teachers were invited to consider and critique a model of vocational aptitude put forward by Clow and Haight (2007), and comment on its relevance to their students. The HE lecturers were also asked about issues of transition between Access programmes and university.

Research questions included:

- In the context of a socially disadvantaged urban area, what does talent in engineering look like in secondary students, post-16 vocational students, and university Access students?
- How do teachers recognise and nurture this talent?
- How do students view engineering?
- How do they prefer to learn?
- What are their plans and aspirations?
- What are the key sources of support and types of constraint operating on their learning?
- What are the key issues affecting the crucial transition between post-16 education and university, especially for talented vocational learners?

Research design and methodology

The research design for the fieldwork element of this study involved:

- a preliminary online survey to establish an overview of the attributes and attitudes of engineering students in the further education college (sample size: 94)
- semi-structured interviews with engineering teachers and students in secondary, further and higher education (sample size: 10 students, 6 teachers).

Baseline survey

The survey was programmed in Zoomerang software, and piloted with engineering lecturers in the college and the Directors of Education at the Stephen Lawrence Charitable Trust. It was completed on a voluntary basis by engineering students on the Specialist Diploma and a range of level 1, 2 and 3 vocational courses. Just over 100 participants completed the survey and 94 consented to their responses being used. Findings from the survey are discussed in Section 2.

Interviews

Semi-structured interviews designed to elicit more detailed, case-study evidence were conducted with engineering teachers and students in secondary, further and higher education. The interviews with teachers focused on ways of defining, recognising and supporting talented engineering students, and on issues of progression and transition between educational levels. The interviews with students followed up information about attitudes, learning preferences and sources of support from the online survey.

The interviews were conducted according to best practice guidelines for research ethics. They were audio taped, with notes made from the recordings. The notes or transcripts from the adult participants were sent to them to allow them to check, amend or clarify their statements.

Report structure

The report is organised into four sections. Section 1 reviews the research literature and key policy developments in the areas of:

- the role of education in promoting social mobility
- gifted and talented education
- engineering education.

Section 2 presents and analyses key findings from the baseline survey with engineering students at the college. Section 3 presents and analyses findings from the case-study interviews with learners and teachers at secondary, further education and university Access levels. Section 4 discusses the research results in light of the literature and policy context, and offers conclusions and recommendations.

An overview of the key findings and recommendations appears in the Executive Summary.

Section 1: Review of the literature and key policy developments

A consideration of issues in identifying and nurturing young people's talent in engineering must begin by reviewing the informing contextual factors in the wider educational environment. This section discusses relevant policy documents and literature in the areas of:
- the role of education in promoting social mobility
- gifted and talented education
- engineering education.

Education, social mobility, and nurturing talent

After its electoral victory in 1997, the incoming Labour government honoured its campaign pledge to invest in 'education, education, education' by addressing key issues on a number of fronts. These included, among a host of others, an emphasis on social justice in education and on recognising and providing effectively for higher-ability learners – an issue that had exercised educationalists in varying degrees since the comprehensivisation of secondary education in the 1970s (Stevens 1980). This focus resulted in the 1999 House of Commons Select Committee on Education report, *Highly Able Children*, which noted a failure in many schools to recognise and provide appropriately for such learners (House of Commons 1999).

The concerns for social justice and for reaching more-able learners intertwined in several programmes designed to identify and provide for such learners from socially disadvantaged backgrounds:
- the Gifted and Talented strand of the Excellence in Cities (EiC) initiative
- the Aim Higher programme
- the Widening Participation agenda.

Although not integrated into a unified, sequenced scheme, these programmes had the remit and potential to nurture 'gifted and talented' learners, at multiple entry points, from primary school to university. Their overall objectives were to encourage individuals to realise potential, to promote a more equitable society and to foster economic competitiveness.

'Gifted & Talented' initiatives in compulsory schooling

The Excellence in Cities (EiC) initiative, launched in 1999-2000, funded specific educational programmes designed to raise standards in disadvantaged urban areas. It included strands on mentoring, behaviour, new technology, working with parents, and providing for 'gifted and talented' learners, a term adopted in 1999 under David Blunkett's leadership as Secretary of State for Education. Over the next 7 years the initiative evolved and expanded. Primary pupils and learners from disadvantaged rural areas were included (via the Excellence Clusters programme) in 2002. The 'Gifted and Talented' (G&T) strand sponsored a national programme of continuing professional development for G&T co-ordinators, and funded local partnerships to support learners, acquire resources, provide enrichment programmes, and embed appropriate teaching strategies within mainstream classrooms.

The EiC initiative was the springboard for introducing a focus on G&T learners to the broader educational sector. This represented a widened remit from the original EiC focus on provision for gifted and talented learners in disadvantaged areas. Between 2002 and 2007 a raft of developments and guidelines emerged to extend, consolidate and integrate provision for gifted and talented pupils in mainstream maintained schools in the compulsory phases, including:

- the National Academy for Gifted & Talented Youth (NAGTY) (2002-2007)
- Institutional and Classroom Quality Standards
- subject-specific exemplification materials and resources
- web-based guidance and learning materials on aspects of identifying and teaching G&T learners
- teacher development programmes for G&T co-ordinators and 'lead professionals'
- the inclusion of G&T issues into Ofsted's rubric for lesson inspection
- London Gifted & Talented, an arm of London Challenge
- the Realising Equality and Achievement for Learners (REAL) project (designed and delivered by London Gifted & Talented), the first national project dedicated to improving the quality of gifted and talented education for black and minority ethnic learners and those with English as an additional language.

A number of these developments were initiated in response to various criticisms of the G&T programme, which remained controversial from the outset. Bonshek (2002) for example, pointed out that central government funding decisions could produce arbitrary and unfair local situations where some deserving schools were excluded from EiC funding. Her research also found that Local Education Authority guidance on identifying gifted and talented pupils in primary schools often relied on behavioural checklists that tended to disqualify such learners from socially disadvantaged backgrounds (Bonshek 2005). In 2005, Gilborn cited the government's own finding that black children were under-represented in gifted and talented programmes, and argued that such programmes perpetuated inequality and represented a type of institutionalised racism in education (Gilborn 2005). White (2006) disputed the validity of what he saw as the programme's underlying paradigm of fixed levels of intelligence. The remit and focus of the 'Gifted & Talented Programme' has continued to draw criticism, most recently, as noted below, from the Panel on Fair Access to the Professions, in part because of the tensions between its initial focus on gifted and talented learners of low socio-economic status, and its later emphasis on providing for learners regardless of social class. At the time of writing, this debate continues, as demonstrated in the minutes of evidence to the House of Commons Select Committee on Children, Schools and Families (House of Commons 2010; Maddern 2010).

Related initiatives in the post-compulsory phases

In tertiary education the widening participation agenda, announced by Tony Blair in 1999, sought to recruit university students from a broader and more representative socio-economic base, and to expand the numbers of young people entering higher education to 50% by 2010. Among over-16s, the Aim Higher programme was designed to foster this expansion by increasing the aspirations, educational opportunities and life chances of young people from 'non-traditional' backgrounds, ie with no family history of higher education. In 2004, the Department for Education and Skills (DfES) funded a programme designed to raise awareness and provide professional development for the teachers of talented post-16 learners on vocational programmes in further education colleges and sixth forms in England (Clow and Haight 2007). This represented an early – and short-lived – effort to consider the neglected population of high-ability learners in vocational education.

Specialist Diplomas

A similar innovation was announced in 2005 as part of a multi-faceted and rapidly changing programme of educational reforms in the compulsory and post-secondary phases that included:

- 'personalisation'
- 14-19 agenda
- a review of secondary qualifications and the attempt to break down the academic-vocational divide (Pollard and James 2004; HM Government 2005; DfES 2005).

The *14-19 Education and Skills* White Paper (2005) set out proposals to improve secondary, post-16 and further education by allowing more personalisation at Key Stages 3 and 4, partly through introducing new Diplomas designed to integrate theoretical and applied knowledge (HM Government 2005). The Specialist Diplomas represent an alternative route to the more traditional GCSE and A-level pathways, and may be combined with them. They are designed to provide progression to other Diploma lines of learning at Levels 1 and 2, and to a range of Level 3 development programmes (including traditional A-levels and apprenticeships). The Specialist Diploma in Engineering was among those introduced in 2008-9.

The Specialist Diplomas have the potential to improve the educational offer to many young people by providing a wider range of subjects, more flexibility, and more applied, work-based learning. They may lead to further and/or higher education, or to apprenticeships. The diplomas seek to build on successful education innovations such as the Increased Flexibility Programme, initiated in 2002. This programme enabled schools to form partnerships with FE institutions so that young people could study at a college for one or two days a week to enhance their vocational and work-related learning. In this they represent part of a movement to recognise and value applied learning (Harkin 2007), and to foster its contribution to talent development.

The educational approach underlying applied learning, Authentic Pedagogy, was formulated by Newmann and Wehlage and includes the following characteristics:

- Students are challenged to think, to develop in-depth understanding, and to apply academic learning to important, real-world problems.
- Pedagogy must include connections to the 'World Beyond the Classroom'.
- Assessment tasks must include problems connected to the world and an audience beyond the school (Newmann and Wehlage, 1999).
- As noted below, these characteristics dovetail with certain pedagogical approaches advocated for high-ability learners, such as those of Taylor and Renzulli.

Harkin's research indicates that school-age students in the Increased Flexibility Programme highly valued the applied-learning approaches and ethos in the FE colleges they attended and experienced increased motivation and self-esteem in their role as learners (Harkin 2005). There is, additionally, evidence of improved educational attainment through such approaches. Casey et al 2006 found higher levels of achievement in both literacy and numeracy when these 'functional skills' were embedded in vocational curricula.

The introduction of Specialist Diplomas represents a key development in the effort to promote educational justice and social mobility. They are designed to dismantle the traditional gulf between academic and vocational education, promote parity of esteem for the latter, appeal to employers and make learning more explicitly employment-relevant to young people. The Skills Council noted with approval that Specialist Diplomas 'have been designed, with high levels of input from higher education institutions and employers, to provide clear and distinct progression pathways through to higher education' (p. 24). It expressed concern, however, that Diplomas will compete with apprenticeships for able vocational learners, who might not necessarily understand the differences between the more 'occupationally specific skills' of apprenticeships and Diplomas' broader 'balanced mix of practical/applied and academic content' (Skills Council 2009: 24).

Vocational education, apprenticeships and higher education

The power of education – and particularly higher education – as a driver of social mobility was a key theme in a raft of policy documents in 2009:

- New Opportunities: Fair Chances for the Future (January 2009)
- Progression through Apprenticeships (March 2009)
- Report of the Panel on Fair Access to the Professions (July 2009).

A key aspect of each of these was the importance of vocational education and apprenticeships both as preparation for employment and, for some, as a route into higher education and the professions.

The issue of social justice in education as a means to social mobility and a more equitable society was considered at length by the 2009 Cabinet Office's Panel on Fair Access to the Professions, chaired by Alan Milburn MP. The Panel was critical of the Gifted and Talented programme of the past decade, on the grounds that its remit was too unfocused and its resources spread too thinly. It noted the programme's lack of support from many schools, particularly regarding the academic ('gifted') elements. These criticisms appear to indicate that the Panel disapproved of the extension of the G&T programme's remit to all maintained schools rather than remaining with the original EiC focus of redressing educational disadvantage. Nevertheless, the Panel advised that many of its recommendations for raising aspirations, including mentoring schemes, improved work experience in the professions and 'soft skill' training, should be funded from a rebranded and refocused Gifted & Talented programme (Panel on Fair Access to the Professions 2009a: 52-3). In the event, this suggestion (which carried a target date of Spring 2010) has been overtaken by events, notably the change of government in May 2010. Even before this the previous government had substantially reduced central government funding for G&T programmes and transferred responsibility for meeting the needs of such learners back to individual schools (Ofsted 2009; Maddern 2010).

The Panel also recommended that the professions, together with governmental agencies such as Sector Skills Councils, work together to establish progression routes from vocational training into both higher education and the professions, and to explore ways in which these routes can be expanded, in particular through:

- the introduction of UCAS points for apprenticeships
- increased partnerships between universities and FE colleges to expand higher education programmes within further education institutions
- fully funded Apprenticeship Scholarships to university for the most talented apprentices (2009a: 83-5).
- The Panel noted that such Apprenticeship Scholarships are particularly appropriate for STEM subjects, including engineering (2009a: 84).

The Panel emphasised the crucial work of further education colleges in promoting social mobility and providing vocational pathways into the professions, noting that learners from the lowest socio-economic groups, part time learners, and learners from minority ethnic groups are much more likely to study in FE colleges than in other types of educational provision. It advised a reconsideration of funding as between higher and further education, and a reduction of the bureaucratic burden on FE colleges of reporting to a range of oversight agencies (Panel on Fair Access to the Professions 2009a: 133-4). The importance of further education specifically to the education of engineers was emphasised by the House of Commons Select Committee on Innovation, Universities, Science and Skills, who emphasised their 'support for the employer-led Skills Academies that are working in this area.' (House of Commons 2009: 99).

Research conducted by the Learning and Skills Council in 2007-08 found especially low levels of intention among apprentices to pursue further formal study directly after completing their apprenticeship, with 0.2% intending to progress to further education and none intending to attend university. These figures are indicative only and may mask a somewhat greater level of attendance, due to the fact that some apprentices may attend university after a period in work, rather than directly after apprenticeship, and often attend part-time rather than full time (Skills Council 2009: 38-9). An earlier study of progression in Modern Apprenticeships also found a relatively high level of intention to progress to higher education among engineering apprentices compared to those in other vocational sectors, such as hospitality (Kodz et al 2000). In its 2009 report *Progression through Apprenticeships*, the Skills Council called for more information about 'non-traditional' learners in higher education, including part-time learners and students who progress into HE as apprentices or former apprentices. This would allow greater monitoring of the attitudes and needs of apprentices to successfully negotiate the transition into higher education. The Council noted the need for bridging courses to help apprentices with certain higher-level academic skills that are not necessarily developed in apprenticeship frameworks, for example essay writing and 'in some cases, such as engineering, advanced maths' (Skills Council 2009: 42).

The issue of vocational pathways into higher education has also been examined recently as part of a suite of academic research projects (funded by the Teaching and Learning Research Programme of the Economic and Social Research Council) designed to investigate widening participation issues in higher education (David 2010). Examining the increase since 1995 in students accessing higher education with vocational qualifications, a research team from Oxford University noted that 'it becomes obvious that vocational routes open access to HE for non-traditional students…Applicants with a vocational background are from lower socio-economic groups, are more often male and from a non-white ethnic background and are more often disabled, than those from the traditional general academic route' (Ertl et al 2010: 79). Retention, however, is an issue. While the drop-out rate for students coming from vocational education and training (VET) is higher than average, a careful analysis of this finding revealed that university students with vocational backgrounds are more likely to drop out of university if their particular institution has a high dropout rate overall. That is, institutional character is more important than either subject or vocational background per se. Students with such backgrounds appear to have a reduced risk of dropout in universities that have a high proportion of VET students (pp. 83-4), although researchers are not clear why this is so.

The importance of 'keeping open the door' to higher-level studies by encouraging students to continue with demanding mathematics was considered by another team of researchers in the same programme. In a study focusing on the early stages of post-16 education, Williams et al found that an institutional culture and classroom approach that emphasise the 'use value' or intrinsic usefulness of mathematics is more likely to retain students than an approach which is driven by the subject's 'exchange value' (ie its potential to earn the school or college a secure place in league tables, or its status value for the student as a 'difficult' subject). The researchers define students' experience of finding mathematics ' "interesting" and "fun" or "enjoyable/challenging" as also part of its use value, in addition to its obvious utility in application' (Williams et al 2010:110). The study found that students are more likely to continue with the level of mathematics that open doors into the study of science, engineering or technology at university if:

- teaching styles are student-centred and 'connectionist' (ie encouraging students to make connections with previous learning and their own experience and interests)
- applied approaches such as the AS 'Use of Mathematics' programme are used.
- The researchers also noted that if policy-makers wish to encourage the study of mathematics to advanced levels, there should be less pressure on schools to focus efforts primarily on C grades at GCSE level (Williams et al 2010: 111-12).

Developing gifts and talents in applied education

General issues in gifted and talented education

Definitions and conceptions

In the decade since the introduction of the gifted and talented agenda, understandings of 'giftedness' and 'talent' have evolved. Debates around the definitions of ability and the claims of social justice and educational inclusiveness have resulted in an emerging reformulation of these terms among specialists in the field (although evidence suggests that this view is patchy in the wider educational sector as a whole) (Balchin et al 2009; Ofsted 2009). This new understanding emphasises multiple types of ability, the importance of motivation and dispositional issues such as resilience, and 'mastery over mystery' (Matthews and Folsom 2009). The DCSF definition of 'talented' now encompasses vocational ability: 'talent' is defined as 'ability or potential in one or more skills, whether artistic, sporting, interpersonal or vocational' (Ofsted 2009: 16).

Since the mid-20th century, there has been a strand of research and theory in the scholarship of gifted education that is amenable to the notion of vocational giftedness. In the 1960s, Taylor's Multiple Talent Theory emphasised the importance, for all learners, of world-of-work abilities such as productive thinking, foresight, planning, communication, decision-making and interpersonal skills. He insisted that if the full range of young people's strengths and abilities were acknowledged, a much higher proportion of learners in an ordinary classroom would demonstrate giftedness in one or more areas (Taylor 1968, 1969).

'Mechanical ingenuity' was listed by Ogilvie in 1973 as one of the domains in which a child could demonstrate giftedness (Ogilvie 1973). In the same decade Renzulli's research on high-achieving adults led him to conclude that intelligence is only one aspect of giftedness. His influential 'three-ring model' includes creativity and 'task commitment' as elements that combine in complex ways with above-average intelligence to produce notable performance (Renzilli 1978). He also distinguishes between 'schoolhouse giftedness' and 'creative-productive giftedness' in real-world contexts, with the latter not necessarily related to academic achievement (Renzulli 2003).

Sternberg's work over the past several decades also explores the multi-variant aspects of 'giftedness' and its fit with real-world issues. His Triarchic Theory combines ‘practical’ with ‘analytic’ and ‘creative’ intelligence, defining ‘practical intelligence’ as problem-solving and the ability to actualise ideas and plans in the real world (Sternberg 1985). More recent features of Sternberg’s work include his influential definition of giftedness as ‘developing expertise’ (Sternberg 2001) and his description of high ability as a synthesis of wisdom, intelligence and creativity (Sternberg 2003). It is worth noting that his term for this ‘WICS’ (Wisdom, Intelligence and Creativity, Synthesised) is a deliberate play on ‘WISC’, the abbreviation of the Wechsler Intelligence Scale for Children, an IQ tests traditionally used to identify gifted children. Sternberg offers an alternative approach to identification that is better equipped than such tests to allow the talent of socio-economically disadvantaged young people to emerge. His protocol includes open-ended tasks such as devising presentations and supplying cartoons with captions (Sternberg 2003: 130-31). Working with educationally marginalised groups such as Native American tribes, Maker has also devised alternative identification approaches that draw on the expertise, educational values and observational skills of community elders (Maker 2006).

The theme of ‘developing expertise’ is extended in the work of Ericcson et al (2007), whose rigorous empirical studies in a number of domains including music, sport, mathematics and chess lead them to conclude that talented individuals require 10,000 hours of practice to become ‘expert performers’. With the exception of certain physical traits such as height and body size in sport, they argue that in virtually all domains deliberate, focused, intelligent practice is more important than innate ability in determining elite performance (Ericsson et al 2007).

Dweck (2006) has discovered that the motivation required for sustained study and improvement depends on learners’ understandings and attitudes toward learning. Her work demonstrates conclusively that students who have a ‘growth mindset’ (the view that capability can be increased with practice and application) show more motivation and achieve more highly that similar students who have a ‘fixed mindset’ (belief in a static model of intelligence) (Blackwell et al 2007).

Teaching approaches

There is wide consensus that more inclusive and well-informed approaches to recognising gifted and talented learners are simply the precursor to the vital task of appropriate teaching, which might be different for ‘non-traditional’ learners. As Sternberg has observed, ‘If [having identified a more diverse group of talented learners] we then only teach in conventional ways, then, of course, we are setting students up for failure’ (Talent and Diversity 1998).

A number of scholars have considered issues in the learning preferences of talented students from ‘culturally diverse and underserved populations’ (Baldwin 2004). Haas and Kies, working with Native American and Canadian First Nations students, have found strong preferences for ‘visual-spatial’ learning among these groups, while at the same time finding similar (if slightly less widespread) preferences among the majority population (Haas 2009). Drawing on a range of research on minority ethnic learners conducted in the United States, Ford and Harris generalise that,
‘minority students tend to be: (a) field-dependent or contextual learners who seek meaning and personal relevance when learning; (b) concrete learners who prefer practical learning experiences; (c) social learners who value interdependence; (d) visual learners; and (e) tactile and kinesthenic learners who prefer active and experiential learning opportunities’ (Ford and Harris 1999: 74-75).

The same might be said of many learners from the majority population, especially young people attracted to applied learning and those with little access to the ‘cultural capital’ available to learners from educationally advantaged backgrounds. Ford and Harris caution that, while these generalisations are guidelines only, such preferences must inform the instructional repertoires of teachers hoping to include the full range of learners in their classrooms.

As with the general population of learners, a number of learners with high potential benefit from teaching approaches that draw on (or simulate) practical, real-world contexts. Several experts in pedagogy for able, gifted and talented learners explicitly recommend this type of teaching. Taylor, for example, advocated the use of classroom experiences that integrate, develop and apply world-of-work skills (productive thinking, foresight, planning, communication, decision-making and interpersonal skills) from primary school onwards (Taylor 1968, 1969). A number of these capabilities (such as prediction, evaluation, creativity) can be linked to the higher levels of Bloom’s taxonomy of learning objectives (analysis, synthesis, evaluation), that gifted education seeks especially to develop (Bloom 1956). Renzulli’s Type III Enrichment activities (advocated for the most able learners on a subject-by-subject basis) involve learners identifying their own, authentic projects driven by real-world needs and resulting in tangible outputs and solutions designed for real-world audiences (Renzulli 2003).

Issues in vocational talent

Definitions and conceptions

More recently a number of studies have considered the issue of giftedness in vocational and world-of-work domains more explicitly. Shavinina has analysed the attitudes and attributes of high-achieving entrepreneurs such as Bill Gates, Michael Dell and Richard Branson. She concludes that individuals demonstrating entrepreneurial giftedness often show scant regard for traditional academic learning as children, do not perform particularly well in school, and have a marked preference for applied, real-world types of learning. They are characterised by a stubborn persistence, an ability to learn from mistakes, and the resilience to keep trying despite initial setbacks (Shavinina 2006 and 2008) – all features of Dweck’s ‘growth mindset’.

A careful longitudinal cohort study by Stamm has demonstrated the presence of learners of exceptionally high intelligence (as indicated by standardised IQ tests) in the ‘lower’, vocational tiers of the Swiss school system (Stamm 2005). In Germany, where vocational subjects traditionally enjoy parity of esteem with academic subjects, an initiative for the ‘Promotion of the Gifted in Vocational Training’ was launched in 1991, accompanied by a programme of research and evaluation. Conclusions from the first decade or so of this programme indicate that vocational learners were characterised not so much by high levels of intelligence or creativity but by high motivation in the areas of both learning and work. Trainees on the programme valued both general and job-specific vocational courses, with those from less academic backgrounds favouring the job-specific courses more highly (Manstetten 2000: 444-5.)

The German and Swiss educational systems embody the configuration of separate types of provision for technical learners originally proposed for the post-war British education system in the Butler Report, but never fully implemented (Jones 2003). Recently, however, the principle of more relevant vocational, technical and work-based education has received renewed attention in the UK. The educational charity

Edge has mounted a national campaign to promote work-based learning, and partnered the Talent Foundation in formulating and publicising a new, employment-relevant model of ability: 'New Kinds of Smart' (Edge; Talent Foundation 2007).

On the eve of a new 'Age of Austerity' in education, Warnock has called for 'radical change' to 'streamline education, and save the money now wasted on the academic bias that still bedevils our educational system.' She deplores the waste 'not only of money, but of the talents of children who all too often find nothing to engage their interest once they have left their primary schools.' Warnock advocates a 'tripartite' educational system after Year 7, divided into academic, technical (ie scientific and technological) and practical courses, with different types of teaching for each, and parents 'encouraged to think of the technical course as the elite' (Warnock 2010: 46-9).

Recognising talent

Whatever modifications to technical and vocational education occur in the forthcoming decade, they are likely to be built on the foundations of the present. Among current National Curriculum subjects in the primary and secondary phases, Design and Technology represents an area in which fledgling talents in technical creativity and application are identified and nurtured.

Lewin identified the subject-specific characteristics of talented pupils in Design and Technology as including:
- the ability to see the same as everyone else and think something different
- a high level of spatial intelligence
- 'good practical and mechanical abilities'
- ability in maths and science
- 'good knowledge of materials, structures, mechanisms and electronics' (Lewin 1999: 10).

These have been expanded by the QCA/QCDA in the past decade to include:
- high levels of technological understanding and application
- hiqh-quality making and precise practical skills
- 'flashes of inspiration and highly original or innovative ideas'
- different ways of working or approaches to issues
- aesthetic, social and cultural sensitivity regarding design issues and evaluation
- rigorous analysis and interpretation of products
- possible frustration at the imposition of rigid approaches to design and making
- the ability to 'work comfortably in contexts beyond their own experience and empathise with users' and clients' needs and wants' (QCDA 2009).
-

At the time of writing it is unclear whether a similar list has been compiled specifically for Engineering, but a number of the D&T identifiers are relevant to talented Engineering learners of all ages.

Generic characteristics of vocationally talented post-16 students have also been identified in recent years. Teachers in Redcar and Cleveland identified a number of characteristics of such learners, including:
- the ability to complete tasks quickly
- pride in their work and attention to detail
- flair and inventiveness
- insight and the ability to see the 'big picture' beyond the task in hand
- the ability to tackle problems in a structured way

- the confidence to speculate, question, evaluate and take risks
- commitment
- the ability to work independently
- ‘practical’ intelligence (Oxford Brookes University 2006: 3-4).

Clow and Haight (2007) synthesised the views of several hundred post-16 teachers asked to identify the features of high-ability vocational learners, and suggest that talent in vocational areas is more multi-faceted than traditional academic ability. Their ‘KAMIS’ model identifies ‘five facets which contribute to success in vocational education’:

- **K**: cognitive attributes such as knowledge, understanding, and thinking skills
- **A**: autonomy; an independence of mind and approach that leads at the highest levels to originality and creativity
- **M**: sensori-motor skills such as steadiness of hand
- **I**: intrinsic drive, motivation, ambition and self-reliance
- **S**: socio-affective traits such as ‘people skills’, that are important in managerial positions associated with career progression (Clow and Haight 2007: 165-7).

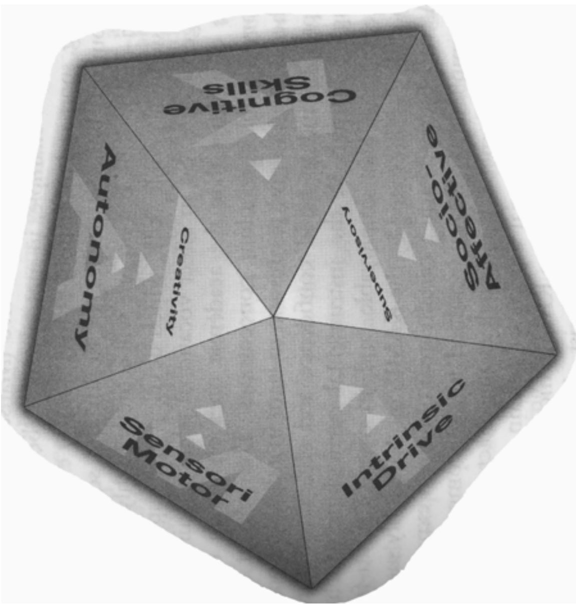


Figure 1.1 The KAMIS model of vocational giftedness

Teaching approaches

It is clear that the versions of authentic pedagogy advocated for gifted and talented learners by Taylor and Renzulli are particularly relevant for talented vocational learners. In addition, as a result of the focus on gifted and talented provision in the wider educational sector, there has been a trend in further education colleges to introduce the principles and practice of differentiation (ie graduated tasks and levels of difficulty, increased pace, challenge and depth, and the design and production of more sophisticated outputs). The need to include higher order thinking skills in vocational education has been argued by Thomas (1992) and Kerka (1999).

In Germany, where there has been a focus on gifted vocational learners for over a decade, teaching and learning approaches include differentiation, special higher-level classes delivered by nominated small businesses and Chambers of Commerce, and preparation for national and international competitions such as the Vocational Olympics (Bals 1999).

An example of an approach to teaching vocational students that integrates a number of features of authentic pedagogy and effective provision for talented students is found in the Lewisham College–Edge document *Perfecting practice, becoming one of us: effective practical learning* This document is aimed at all learners, not specifically those with high potential. The approach is based on the notion of a 'learning entitlement,' and states that 'good practical learning should provide opportunities to:

- join the world of work
- learn from experts
- learn by doing
- grow into the job
- learn and work in a team
- learning through solving problems
- recognise and make the grade
- prepare for the future (Lewisham College–Edge, nd, c 2005:4).

This stance shares a number of the concepts and principles already examined, including:

- Newman and Wehlage's Authentic Pedagogy
- the world-of work focus and interpersonal skills emphasised by Taylor
- Sternberg's notion of 'developing expertise'
- Renzulli's problem-based learning (Type III enrichment).

Issues in engineering education

Status and perceptions of engineering

Engineering is a comprehensive and flexible domain that encompasses, and potentially allows movement between, craft and professional occupations. Whether, and how often, this occurs in practice depends on individual motivation and opportunity, structural issues in the wider educational context, and the availability of preparatory and 'bridging' provision that allows learners to move from the more applied, vocational sphere to the more abstract, numerate and literate content of academic and professional learning (Skills Council 2009: 42).

In a shift from its status in earlier decades, engineering is now among the group of professions where the proportion of members from wealthier-than-average families is rising (Panel on Fair Access to the Professions 2009b:14). The availability of opportunities to join the profession is vital but young people must be sufficiently willing and motivated to take them up.

The need for a change in the perceptions of engineering among young people, parents and teachers has been highlighted in a recent report commissioned by the National Grid (2009). The study found that engineering is 'almost an invisible industry', with jobs in engineering perceived to be 'menial, dirty and about fixing things'. Parents and young people ranked engineering below medicine, teaching and policing as a profession that makes a key contribution to society. These negative perceptions threaten essential recruitment to the industry. The study found that ten times as many boys as girls would consider a career in engineering (39% of boys, as opposed to 4% of girls) (p. 11). The perception that engineering is a career for men, not women, was especially prevalent among the BME parents surveyed in the study. (p. 9) The report emphasises the need to improve the image of engineering by publicising its impact on society, creative aspects and close connection to technology, and by adding 'aspiration and allure to engineering careers'. This should be achieved by a systematic campaign through all phases of education to raise awareness of engineering through school visits and especially by meaningful work experience (p. 4).

While doubts have been raised recently about the validity of assumptions automatically equating higher education with better job prospects and higher pay (and consequently with social mobility) (Brown et al 2008), it may be assumed that the higher levels of engineering will continue to recruit employees in the UK (and perhaps around the world). The House of Commons Select Committee was impressed by the high regard in which British engineers and UK engineering are held in China and Japan (p. 104). The National Grid alone anticipated the loss through retirement of around one-third of its workforce and forecasts the need for 1000 additional jobs in the decade to 2020 (National Grid 2009a: 3; National Grid 2009b). Engineering is also, of course, well placed to position learners for apprenticeships and vocational positions, with the employment and career prospects that these afford.

Engineering education through the phases

The National Grid report found that, in secondary schools, some science and maths teachers were embarrassed by their lack of knowledge about engineering and therefore unlikely to recommend it to students as a career option. This was not the case for FE teachers, who had often worked as engineers themselves and viewed the profession positively. (pp.7,14).

In the workplace, the ‘engineering apprentices interviewed had often chosen their career path despite discouragement from teachers and parents’ (p. 9). Where this was not the case, a ‘significant number’ of young engineers in the study had a family connection with engineering, and this had influenced their decision to enter this occupation (p. 14)

In terms of approaches to counter misconceptions and publicise engineering more effectively, both young people and teachers surveyed felt that meaningful work experience was likely to be the most effective measure (61% of young people and 97% of teachers felt this would have the most impact) (p. 20). Other measures young people would like included meeting engineers and visiting workplaces to see what they do. Teachers, however, were not enthusiastic about approaches that required co-ordination with business and industry, as their professional performance is judged on their students’ exam results, not on their occupations after they leave school. They were sceptical about engineering businesses offering relevant work experience placements, feeling that these might ‘turn out to involve sweeping up and making tea’ (p. 22).

The report found that young people, teachers and parents did not yet have a clear idea about the Engineering Diploma. Parents were worried about their children being used as ‘guinea pigs’ to test the new award. Young people were unclear about the relative status of the Diploma relative to other qualifications and awards, and were concerned about specialising too early. Some of the FE teachers expressed concern about the shortage of specialist teachers qualified to teach engineering, noting that the Diploma currently relied on D&T teachers (p. 24). This shortage was also noted by the House of Commons Select Committee, which also emphasised the importance of good careers advice (p. 98).

Engineering and mathematics

Engineering is one of the core STEM subjects, requiring advanced mathematical proficiency to move to the higher levels. Newman-Ford and colleagues (2007) evaluated the performance of engineering undergraduates who entered university without A-level mathematics due to ‘a serious decline in students’ mastery of basic mathematical skills and level of preparation for mathematics-based degree courses’ (Newman-Ford et al 2007: 2). This is partly due to a decline in entries to A-level mathematics from around 85,000 in 1989 to 53,000 in 2004, although since then numbers have increased to 73,000 in 2008. The study reports that:

Engineering Mathematics is a key facet of all engineering degree courses. However, the decline in engineering recruitment [to Higher Education programmes] and the implementation of widening access policies have resulted in institutions recruiting students with diverse backgrounds, including those with deficiencies in mathematics and physics which form the basis of traditional engineering education. This has resulted in increased dropout rates and poor student progression. In fact, research suggests that failure and premature withdrawal during the first two years of undergraduate programmes are primarily caused by the difficulties students experience acquiring necessary mathematics skills (Newman-Ford et al 2007: 2).

A decline in mathematical proficiency for engineering has been a concern in the profession since the 1990s. In 1995, a study conducted by professional bodies representing a range of specialisms, including mechanical, civil, chemical and electrical engineering, found that students beginning engineering degree courses had insufficient levels of mathematics. The problem appeared to be related to an erosion in traditional academic qualifications in mathematics. The report found that ‘students with an A-level pass in mathematics now enter higher education less well prepared in mathematics than the equivalent students ten years ago,’ particularly in algebraic manipulation, trigonometry, calculus and complex numbers, and graphical skills. The study warned that the situation required urgent action “to reverse the downward drift in standards created by the general movement where all engineering courses, regardless of the ability of the intake, claim that they are providing education for chartered engineering status” (Patel 1995).

Once learners succeed in gaining a university place to study engineering, many struggle with mathematics. Writing of undergraduate engineering students, Sazhin (1998) observed,

One cannot expect engineering students to perceive mathematics in the same way as professional mathematicians usually do, yet the professional engineer must acquire not only empirical but also abstract understanding of mathematics. It seems that the objective of teaching mathematics to engineering students is to find the right balance between practical applications of mathematical equations and in-depth understanding….It should not be taken for granted that engineering students understand the need to study mathematics in the first place (Sazhin 1998: 1).

In 2003, Smith reported that the UK is one of the few European countries not requiring mathematics as a compulsory aspect of post-16 education. In the UK fewer than ten percent of post-16 students continue to study mathematics; of these fewer than ten percent continue to study for a mathematics degree at university (Smith 2003).

The Department for Education and Skills (DfES) commissioned the National Foundation for Educational Research (NFER, 2009) to conduct research into deployment in mathematics and science departments in one in four maintained secondary schools in England during the academic year 2004-2005. The study found that 24 per cent of teachers deployed to teach mathematics were non-specialists or were predominately teachers of other subjects. Maths teachers who were not specialists in the subject were most often found in the lowest attaining schools, those serving areas of socio-economic deprivation and those with an 11-16 age range. For example, 21 per cent of maths teachers from schools with the lowest GCSE results did not hold a post-A-level qualification in the subject. The comparative figure for schools with the highest GCSE results was 9 per cent. A similar pattern also emerged for schools with higher than average numbers of pupils eligible for free school meals (FSM) and those with higher numbers of pupils with special educational needs (SEN). For example, in the teacher sample, around a third of maths teachers from schools with the highest levels of eligibility for FSM held a degree in the subject compared with well over half in schools with the lowest eligibility levels. Imbalance was also evident within schools in terms of pupils' ability: for instance, in maths, pupils set in designated 'low ability' groups had an increased chance of being taught by a teacher without a post-16 qualification in the subject. In determining how to deploy all available teachers to maths and science classes, heads of department reported that they gave priority to year groups and courses that involve national assessment: Year 9, GCSE and AS/A2-level (NFER 2009).

The BBC reported in June 2008 that the Training and Development Agency for Schools had spent £40m on teacher recruitment over the previous five years, largely focussed on the priority subjects of maths and science, with some success. Nevertheless, maths graduates are in very high demand and difficult to recruit to education, despite financial incentives. One of the problems faced by the TDA is the decrease in students studying science and maths at A-level and degree level, resulting in a relatively small pool of maths graduates from which to draw (BBC 2008). On the other hand, there is evidence that in the current economic downturn, this trend is reversing, with redundant financial workers showing interest in retraining as teachers. Some providers of teacher education are specifically targeting finance workers to retrain as maths teachers, and the Training and Development Agency continues to offer the highest financial incentive to trainees of STEM subjects (Leeds Trinity University College 2009; London Evening Standard 2010; TDA 2010).

The Royal Society, reviewing the participation and attainment of 14–19 year olds in science and mathematics in the UK between 1996–2007, found that:

The evidence available clearly suggests that the wave of recent educational reform has not yet had the effect of driving up participation to the desired extent. Ongoing educational reform, particularly in England, has made it very hard to discern with certainty the impact of any one initiative. (Royal Society 2008:17).

The review found that prior attainment is the single biggest predictor of progression to post-16 study in science and mathematics, and that, other factors being equal, the study of separate sciences prior to 16 results in an increased likelihood of progression. Contrary to some popular conceptions, the review found that,

Large-scale international (comparative) studies indicate that the UK's performance is comparable to that of other industrialized nations, … [its] performance in science education is above the mean for OECD countries … [and its] performance is not significantly below the OECD mean in mathematics (Royal Society 2008: 19).

However, of particular relevance to this study, comparative studies show that there are relatively low proportions of UK students attaining at the higher levels in mathematics (Royal Society 2008: 19). The Royal Society recommended further research into:

- the reduction in post-16 students' participation in science and mathematics, with particular scrutiny of students' decision-making processes and actions
- patterns of participation and attainment among different socioeconomic and ethnic groups, analysing information from large national datasets (p. 20).
-

The FE teachers interviewed in the National Grid study were concerned about the lack of integration of the needs of industry into the school curriculum, 'feeling that maths and science teaching is geared for academic "stars", not for mainstream use'. The apprentices interviewed 'enjoyed the more practical maths and science activities', but found A-levels in these subjects too 'difficult and theoretical', and aimed at more academic students. '[T]hey say that they now enjoy using maths more at work than they did at school' and 'now understand the applications of these subjects and use them in a more meaningful and more practical way' (p. 14). (National Grid 2009: 14). These findings confirm a recent TLRP study into 'keeping open the door' into STEM subjects through encouraging post-16 mathematics. The study found positive results from connectionist teaching approaches and the use of applied maths syllabuses (Williams et al 2010: 111-12).

Summary

The Labour administration of 1997 to 2010 pursued a policy of using education to foster social justice and mobility among socio-economically disadvantaged groups. The Gifted and Talented agenda and widening participation initiatives were designed to promote these aims. In the case of the former, however, additional educational goals and emphases, distributed in a more widespread and 'socially-blind' way, meant that the aims of redressing educational disadvantage for talented learners were not always realised.

At the same time, a focus on 'under-served populations,' including minority ethnic and socially disadvantaged learners, became more important in the international field of gifted and talented education. This was part of a wider trend from 'reductionist' models of ability premised on cognitive ability tests, to more 'emergentist' models that focus on developmental, contextual, dispositional and behavioural aspects such as motivation, 'mindset,' effort and practice.

The area of vocational talent is relatively under-explored, although one model (Clow and Haight 2007) hypothesises that this type of ability depends on a wider and more rounded set of capabilities than more traditional academic ability. There are approaches to teaching gifted and talented learners that take this wider set of capacities into account (Taylor 1968, Renzulli 2003) and have the potential to work well with talented vocational learners, who respond better to an 'authentic pedagogy' (Newman and Wehlage 1999; Lewisham College–Edge) focused on applied learning in real-world situations.

A number of policy documents concerned with social mobility, skills development and the status and future of engineering emphasise the crucial role further education plays in providing educational routes for vocational learners, including those who wish to develop their skills to degree and professional levels. There are still notably low levels of black and minority ethnic (BME) and female engineers and engineering students. For engineering students in all phases, perceptions in the status of the profession and gaps in mathematical proficiency are key issues.

Section 2: Findings from the baseline student survey of attitudes and learning preferences

An online survey of student attitudes, learning preferences and aspirations was completed by 102 students on Specialist Diploma and vocational Level 1, 2 and 3 engineering courses in the college, of which 94 consented to have their responses used in the study. It was administered in college computer suites during tutorial periods in November 2008.

Ethics

The administration, conduct and analysis of the online survey adhered to best-practice ethical principles recommended by the British Educational Research Association and Oxford Brookes University. In advance of completing the survey, participants were supplied with an information sheet explaining the study and stating that Oxford Brookes University was conducting it on behalf of the Stephen Lawrence Charitable Trust. This emphasised the voluntary and anonymous nature of taking part in the survey, and stressed that non-participation would have no impact on students' grades or standing in their courses. A short paragraph at the beginning of the survey itself reiterated its purpose, sponsors, and voluntary nature. In the survey itself, student consent was obtained through the first question, where participants could agree or disagree with the statement 'The information I give in this survey can be used in the study for the Stephen Lawrence Charitable Trust.' This allowed the responses of non-consenting participants to be filtered out. Of the 102 participants completing the survey, 94 gave permission for their responses to be used. The responses of the non-consenting 8 respondents have not been used in the analysis of findings, although one interesting sidelight is that 2 of these respondents (both on Level 3 courses) indicated a desire to go to university. One of these individuals was in fact identified as a talented student and agreed to be interviewed for the study. (At interview, he gave retrospective consent for his survey responses to be included in the study.) This does highlight a limitation of the findings, illustrating that at least some of the students the study specifically sought to investigate refused permission for their responses to inform it.

The survey relied on students' self-reports, and the research team has assumed these to be truthful. At the recommendation of the college tutors, the survey included a box for participants to fill in their student number, in order to encourage them to take the survey seriously and discourage frivolous answers. No students had their survey responses individually traced back to them, with the exception of the 4 secondary students and 3 further education students selected for interview. Informed permission (via information letters and signed consent forms) was obtained from each student, and the parents of the secondary students, in advance of comparing their online responses with the information supplied in the interviews. Only the Oxford Brookes research team had access to students' survey responses.

Purpose and content of the online survey

The online survey was designed to elicit a picture of the engineering students in the college and an overview of their learning preferences, motivations, sources of support, and aspirations. (For survey questions, see Appendix 1.) This picture is of interest in its own right, and also serves as contextual and comparative information for the interviews with the engineering teacher and lecturers, and with the students nominated as being talented in engineering.

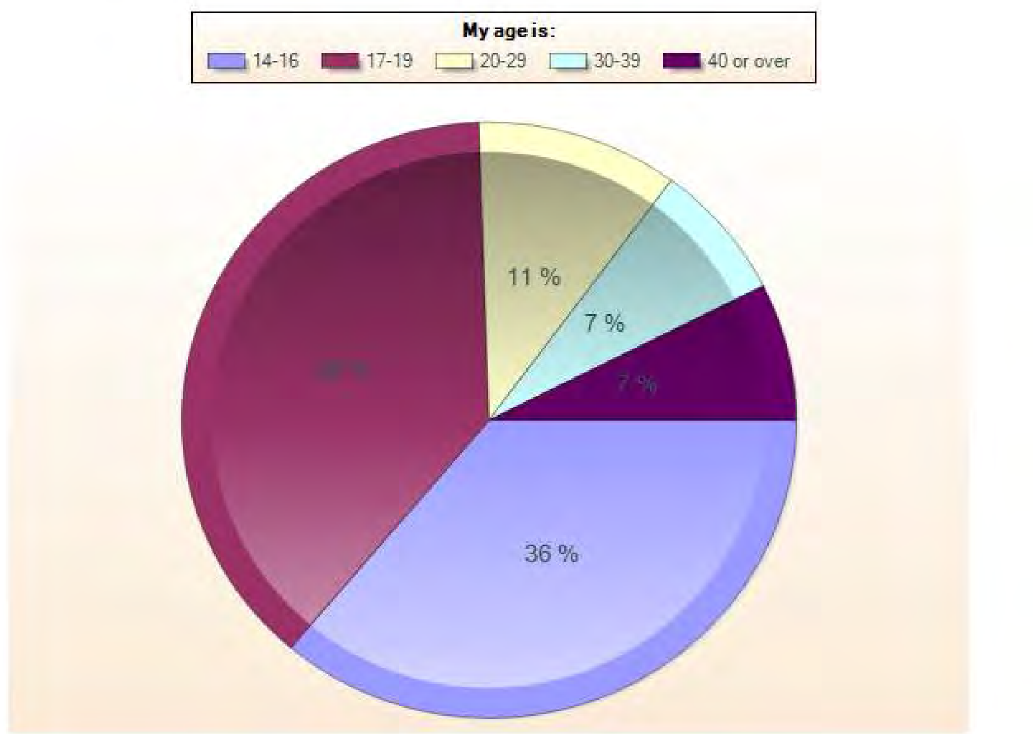
Students' background information

The survey obtained the following background information about students.

Age and gender

Thirty-six percent of students were aged 14 to 16. Thirty-eight percent were between 17 and 19. Eleven percent were aged 20 to 29, with 7 percent between 30 and 39 and the same proportion aged 40 or over.

Figure 2.1 Age of survey respondents



Ninety percent of respondents were male, and 10% female. This is in line with the finding of the recent National Grid study that boys are ten times more likely than girls to express a desire to have a career in engineering (2009:11).

Ethnicity

Standard categories from the Equality and Human Rights Commission were used to ascertain information about ethnicity. These categories are routinely used by the college in its own student information forms, so students are used to describing themselves in this way. Responses are shown in Table 2.1. In overview, 38% of respondents self-identified as Black and 39% as White, with various other categories making up the remainder of the sample. No participants identified as Chinese.

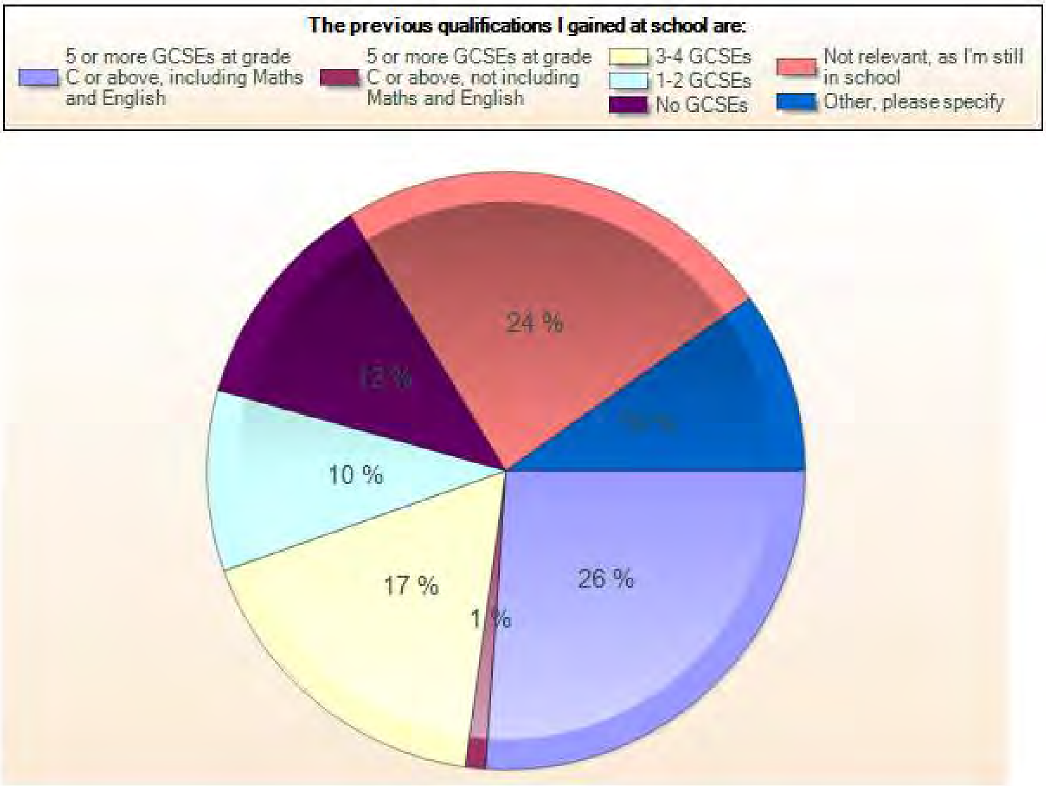
Table 2.1 Ethnicity of survey respondents

Bangladeshi	0	0%
Indian	0	0%
Pakistani	1	1%
Other Asian/Asian British	3	3%
Black/Black British: African	15	16%
Black/Black British: Caribbean	16	18%
Other Black/Black British	4	4%
Chinese	0	0%
Mixed White/Asian	2	2%
Mixed White/Black African	3	3%
Mixed White/Black Caribbean	2	2%
Other Mixed heritage	1	1%
White British	25	27%
White Irish	1	1%
Other White	10	11%
Other	8	9%
Total	91	100%

Previous qualifications

Nearly one-quarter of the respondents were still in school, and so had no previous qualifications. Twelve per cent had no GCSEs. Ten percent had one or two GCSEs; 17% had 3 or 4. Twenty-six percent had 5 or more GCSEs at C or above, including Maths and English. One respondent (1%) had 5 or more GCSEs at grade C or above, not including Maths and English. A further 10% of students had ‘other’ qualifications, such as those obtained abroad.

Figure 2.2 Previous qualifications of respondents



Twelve per cent of participants were apprentices (n = 11).

Current course

Nineteen percent of participants were studying on the Specialist Diploma in Engineering. This meant that they were in college for one day a week during term, with the other four days spent in their secondary schools. Other respondents were undertaking various Engineering courses in the college:

- 18% on a Level 1 NVQ course
- 33% on a Level 2 NVQ course
- 15% on a Level 3 NVQ
- 5% on a BTEC National course
- 3% on a college pre-Level 1 access course
- 6% on other courses, such as pre-Level 1 'entry' courses.

Students' learning preferences

The survey sought information about the learning preferences of the engineering students. While the research evidence for various claims about the existence of 'learning styles' has recently been discredited (Coffield et al 2004), it is still meaningful to invite students to offer their own views about how they prefer to learn, what they see as their own strengths and weaknesses, and how they view their subject in general. This information was elicited through two sets of open-ended questions:

- 'The part of the course I am best at' / 'The part of the course I am worst at'
- 'The part of engineering I like best is' / 'The part of engineering I like least is'.

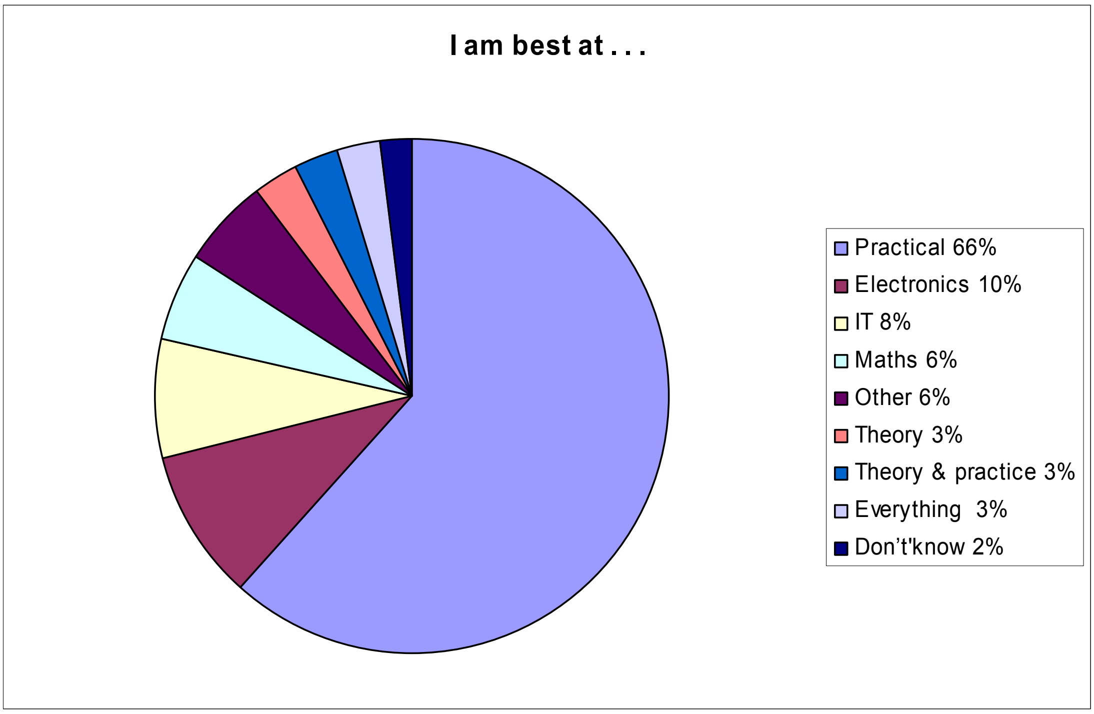
Students' open-ended responses were then coded and analysed.

A question with closed-response options also asked students to rank their reasons for doing the course ('I decided to do this course because:'). Three response options related to extrinsic motivators in the respondent's lives, such as influences in their family or social life, or employability:

- 'Someone in my family is in engineering'
- 'A friend is doing a course or works in engineering'
- 'It will help me get a job'.
- The other response options, however, related to intrinsic aspects of an individual's engagement (both intellectual and practical) with the domain of engineering:
- 'I like the maths'
- 'I like the problem-solving'
- 'I like knowing how things work and being able to fix them'
- 'I like practical, hands-on work'.

Analysis of students' responses to both the open and closed questions reveals a clear affinity for the practical aspects of their engineering courses. This is most striking in respondents' answers to the prompt: 'The part of the course I am best at', where two-thirds of the 87 responses (n = 57) related to practical work. Individual responses included variants such as 'hands on', 'building', 'fixing', 'making', 'soldering', 'repairing', 'mechanical', and 'workshop'. This compares with the other one-third of participants who reported that they are best at the more abstract, conceptual aspects of the course (for example, electronics, IT, maths, theory, 'everything').

Figure 2.3 The part of the course I am best at:



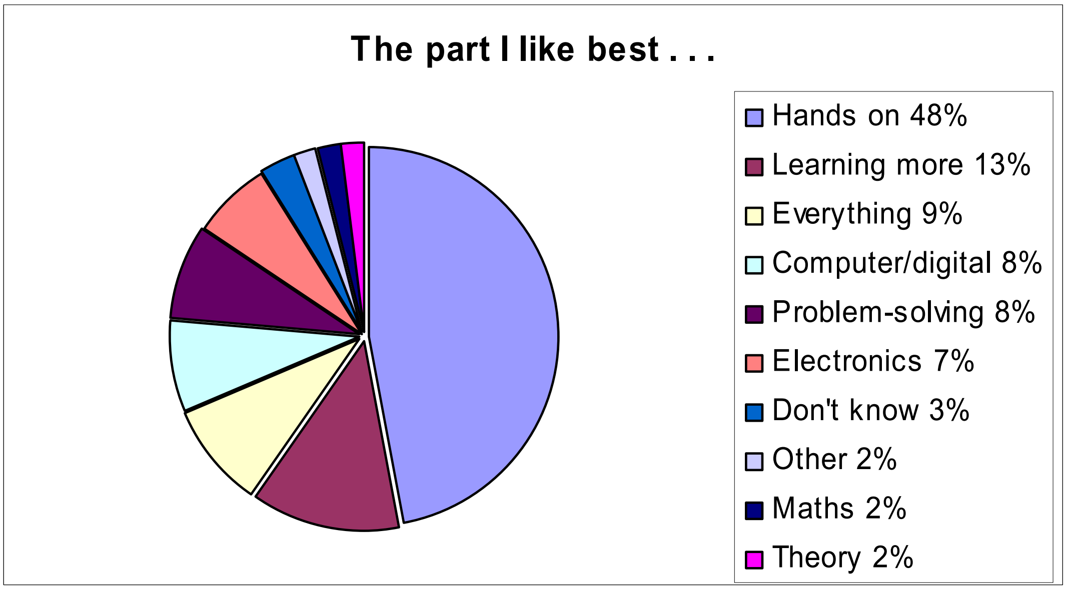
In the closed-option question asking about their motivation for doing the course, 60 students (64% of total respondents) ranked the responses:

- 'I like knowing how things work and being able to fix them' or
- 'I like practical, hands-on work'

as either their strongest or second strongest motivation (out of 7 options). Nineteen students (20%) ranked these in the weakest two categories of motivation.

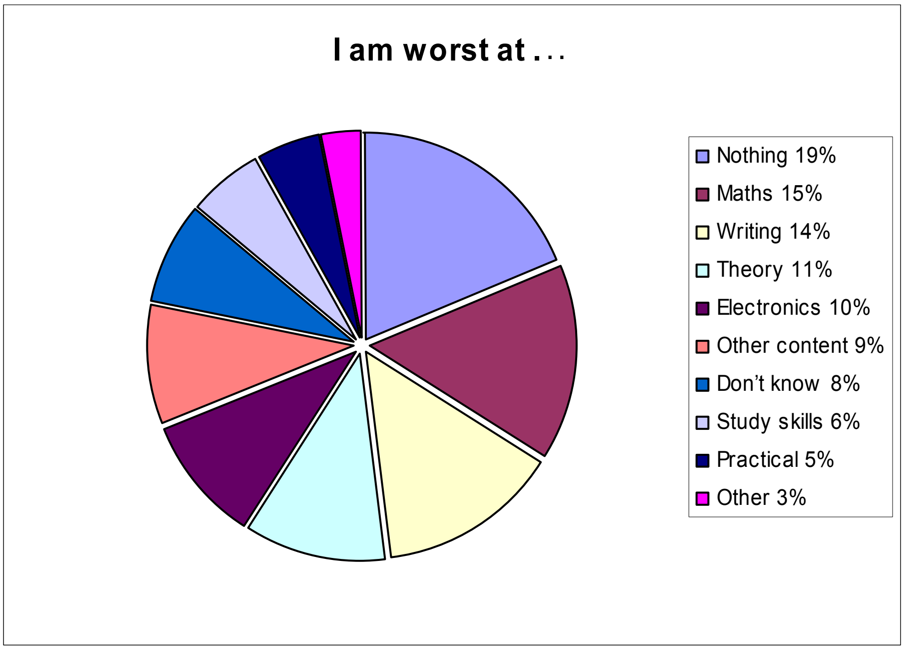
This is in line with responses to the open-ended question about what part of the course students liked best. Nearly half the students (48%) reported that they liked the 'hands-on' aspects of their courses the best, giving responses such as 'practical', 'fixing the bikes', 'soldering and fixing stuff', and 'making things'. When problem-solving and design aspects (8%) are added to this, the number rises to 56%. Thirteen per cent of students gave responses that indicated a love of learning or increasing their understanding (including one whose favourite aspect was 'exams'). Nearly one-fifth (19%) cited conceptual aspects (such as computer- or digital-related work, electronics, maths and theory) as their favourite part of the course. It is worth noting that no student indicated a preference for the 'writing-up' aspects of the courses.

Figure 2.4 The part of engineering I like best is:



Respondents gave more varied answers when they were asked to name 'the part of the course I am worst at'. Nearly one in five of the 80 respondents (n = 15) claimed that there was nothing they were 'worst' at, with responses including 'nil', 'not one thing', 'nuffin', 'am gd at everything', and 'No I try hard'. Interestingly, this is the largest area of response to this question, and significantly extends the 3% who said they were good at everything.

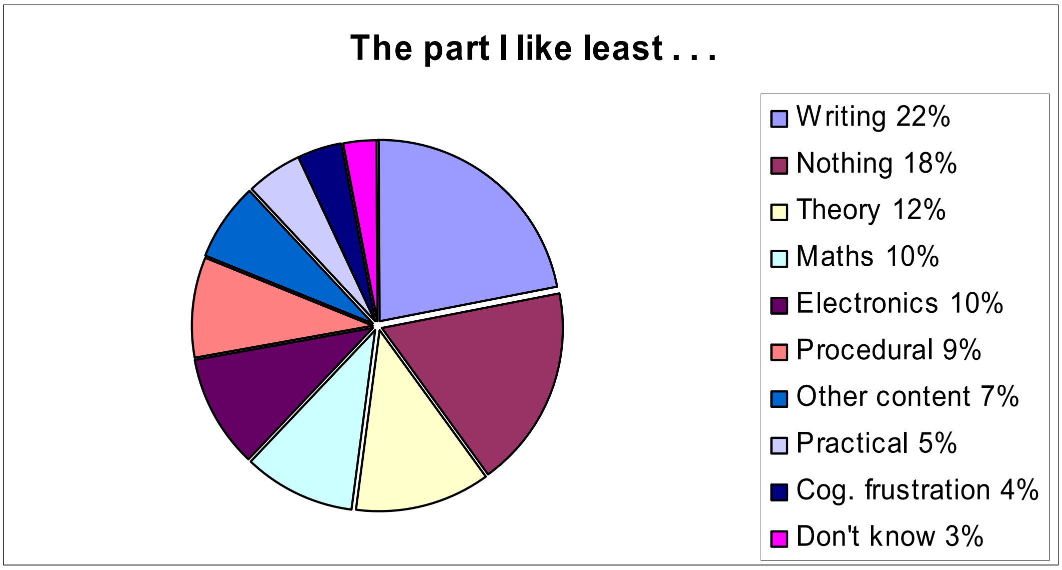
Figure 2.5 The part of the course I am worst at:



Only 5% of students reported the practical aspects of engineering as their worst areas, while 45% reported that abstract conceptual areas (such as maths, theory and electronics) were their worst areas. One-fifth reported literacy and writing (14%) and other study skills such as 'remembering' and 'taking notes in theory lessons' (6%) to be their most troublesome areas. One student reported that he or she was worst at 'attendance' an aspect of the course that the college stresses heavily.

In terms of 'the part of engineering I like least', the most frequently cited area of dislike was writing (22%), which included responses such as 'the English', 'literacy' and 'coursework'. Paralleling the number who said there was nothing in their course they were 'worst' at, nearly one in five students (18%) gave answers indicating that there was nothing in their courses that they didn't like. Nearly one third of students (32%) disliked various conceptual areas such as theory (12%), electronics and maths (10% each), and another 7% disliked various engineering-specific content areas such as 'brakes', 'engines', and 'resistors colour codes'. Five percent disliked practical aspects such as 'taking things apart', while 9% indicated they disliked procedural issues such as 'getting dirty' and 'clearing away'. A few (4%) expressed cognitive frustration, including 'frustrating when a solution escapes you', 'think how to solve a problem', and 'remembering all the names of the pieces'.

Figure 2.6. The part of engineering I like least:



Motivation and support

As noted above, students were invited to rank a given set of options to explain their decision to do their engineering course. There were three 'extrinsic motivators' listed:
'Someone in my family is in engineering'
'A friend is doing a course or works in engineering'
'It will help me get a job'
and four 'intrinsic motivators' related to individual engagement with the domain of engineering:
'I like the maths'
'I like the problem-solving'
'I like knowing how things work and being able to fix them'
'I like practical, hands-on work'.
The survey software did not allow equally weighted responses, ie each of the eight rankings could only be used once for a response option, so a participant could not give equal first ranking to two different responses.

A striking result is the high ranking students gave to the intrinsic motivators. Ninety percent of students (n = 85) gave a first or second ranking to one of the intrinsic options. The most highly ranked motivator was 'I like practical, hands-on work' (38%), followed by 'I like knowing how things work and being able to fix them' (25%); 'I like the maths' (15%) and 'I like the problem-solving' (12%).

In contrast, 35% of students gave an extrinsic motivator a first or second ranking. (Percentages do not tally to 100 because of the structure of the question and the analysis, which includes both first- and second-ranked responses.) Of the extrinsic motivators, the most highly ranked was: 'It will help me get a job' (18%), followed equally by 'Someone in my family is in engineering' and 'A friend is doing a course or works in engineering' (8.5% each).

For the question 'Who encouraged you most to do this course?' students were invited to rank the following options:

- careers adviser
- friend

- teacher
- family member
- faith group or community contact
- other.
- The largest proportion of students (35%) ranked ‘family member’ highest or second highest. The next most highly ranked option was ‘other’, with 23% of students selecting this as their first or second choice. It is possible that some of this group of ‘encouragers’ were employers, but this is conjecture. The rest of the options received the following rankings (in first or second place):
- friend (16%)
- teacher (15%)
- careers adviser (7%)
- faith group or community contact (4%).
- Of note here is the low ranking students gave to ‘careers adviser’. This is in line with the findings of the Panel on Fair Access to the Professions on the general weaknesses in careers advice (2009: 73-77), and the findings from both the House of Commons Select Committee for Innovation, Universities, Science and Skills (2008: 98), and the National Grid study (2009: 7,14) on the lack of good careers advice about occupations and training requirements in engineering.

Support for learning

Students were offered a similar closed-response question to identify ‘who helps you most when you need to understand something hard in your course’. Forty-six percent of respondents (n = 43) ranked their teachers or tutors in either first or second place. Twenty-four percent gave a first- or second-place ranking to the option ‘figuring it out by myself’. For the remaining options, students gave first or second ranking to:

- my family (16%)
- other students (13%)
- my friends (12%)
- my work mates (9%).

These responses highlight the crucial role of teachers in a demanding technical subject (perhaps especially important in an area with high levels of social disadvantage), but also attests to learners’ awareness of the need for individual effort and persistence in order to master difficult content.

Students’ aspirations

The research team attempted to elicit a sense of students’ expectations for the future through the question: ‘After my course is finished, what I’d most like to do is:’ followed by a number of response options indicating a range of employment- or education-related choices. (These survey options were mutually exclusive, that is, students could only select one.) Again, it is worth emphasising that the responses represent students’ self-reports, and it is not possible to ascertain whether these should be interpreted as realistic plans, hopes, expectations, preferences, fervent personal ambitions, parental desires or outright pipedreams. Nevertheless, the students’ responses to this question do give some indication of their thinking and aspirations for the future.

In this sub-section, students’ responses are considered first in total, before being analysed according to:

- age
- ethnicity

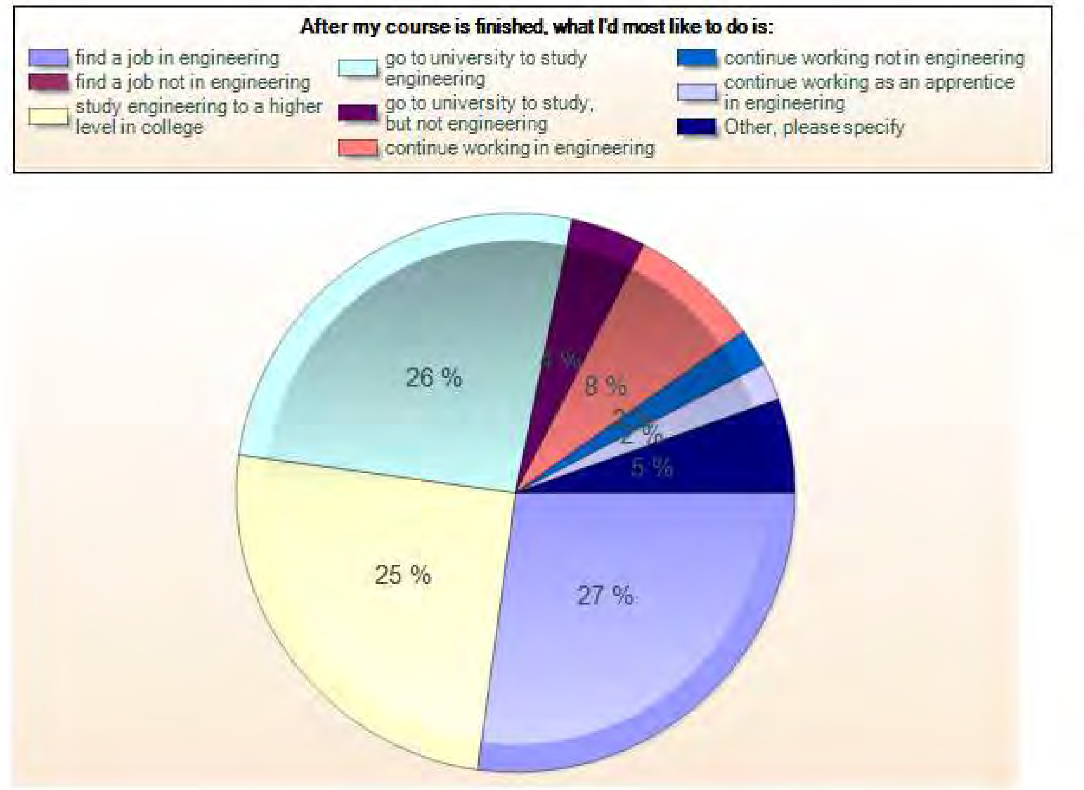
- gender
- level of course studied.

Aspirations of total respondent group

When asked what they would most like to do after their course was finished, the majority of respondents (88%) indicated that they would like to continue some type of involvement in engineering. This is perhaps unsurprising, given the vocational nature of the courses and the investment in time and opportunity costs that students need to make. The college's location in a disadvantaged borough of London makes it likely that students would need to consider carefully the future financial return on investment of their time and money in their choice of course.

This is reflected in the fact that over one quarter (27%), indicated that they would like to move into an engineering job after their course. Just over half of respondents reported that they would like to continue to study engineering, either progressing to more advanced courses in the college (25%), or studying engineering at university (26%).

Figure 2.7 Respondents' after-course plans

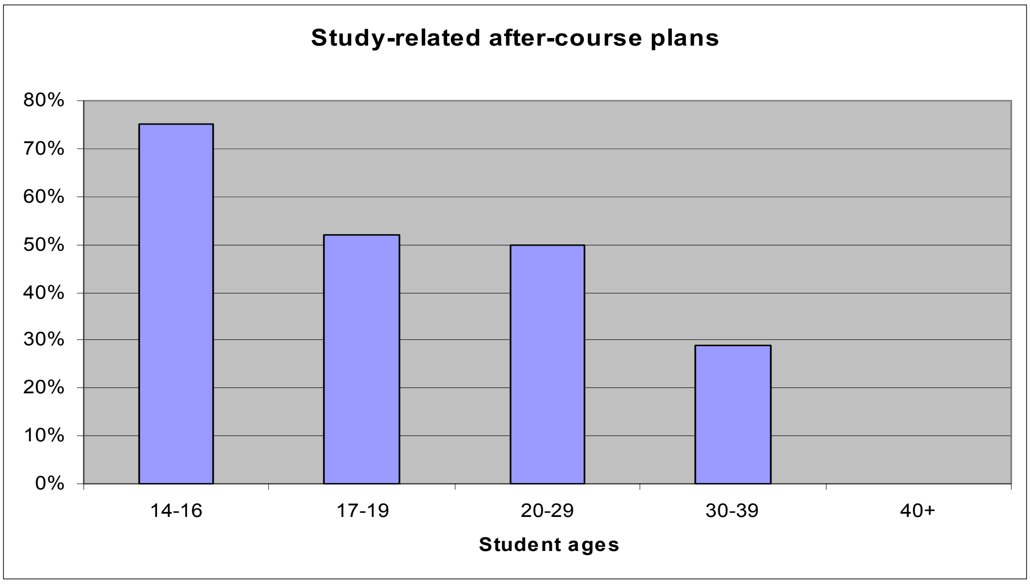


After-course plans and respondents' ages

Responses to this question were compared according to the participants' ages, and expected patterns of reported plans emerge, with younger people indicating greater aspirations to continue studying engineering. This is in line with intuitive expectations that younger people in earlier life stages, with fewer responsibilities and less exposure to life outside education, would be more likely to anticipate continuing their studies. Percentages of survey respondents indicating study-related plans after their current course are shown in Table 2.2. These results are indicative rather than generalisable, as the sample sizes of the various age groups varied considerably:

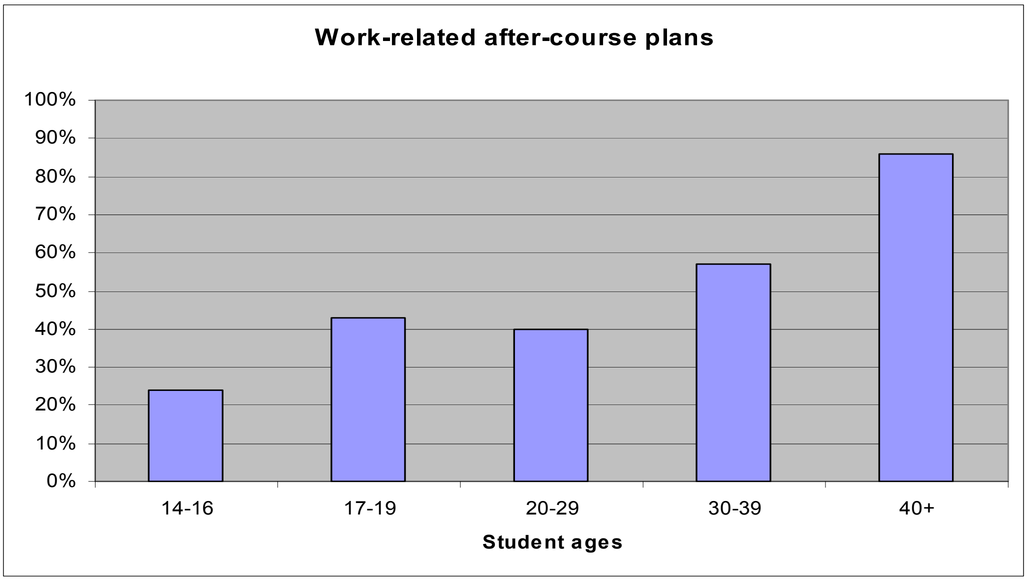
- 33 respondents between 14 and 16
- 36 respondents in the 17-19 category
- 10 repondents in their twenties
- 7 respondents each in the 30-39 and 40-and-over age ranges.

Table 2.2 Study-related after-course plans, by age group



Again unsurprisingly, there was a mirror-image pattern of results showing work-related plans against the ages of respondents. This is shown in Table 2.3, which illustrates the proportions of students intending either to find or continue in employment. Students' plans to pursue work-related activities after their courses increased with age.

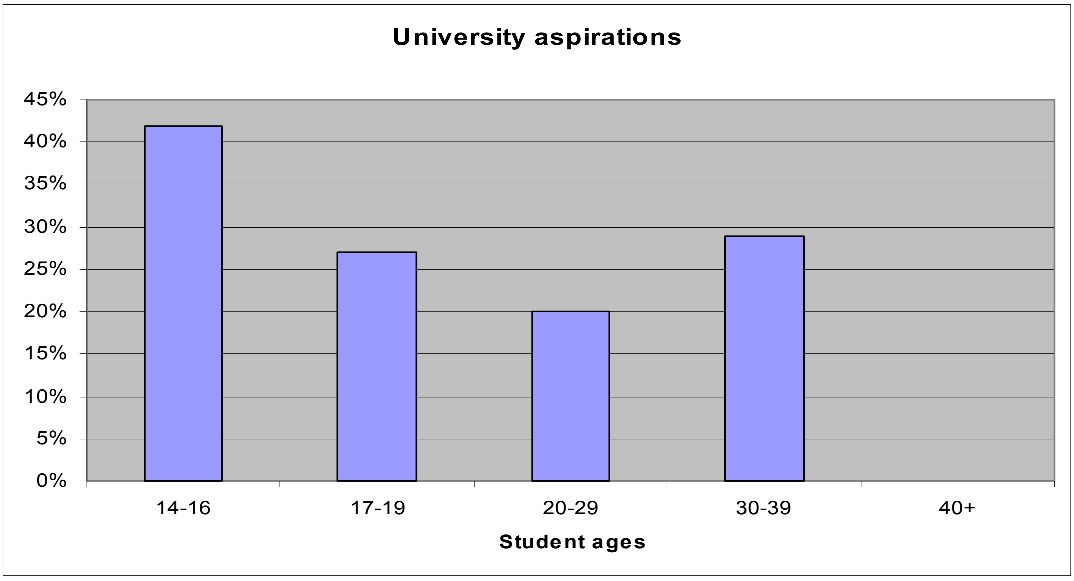
Table 2.3 Work-related after-course plans, by age group



University aspirations and students' ages

The Panel on Fair Access to the Professions praised engineering as a profession with a variety of entry routes, including vocational ones, but observed that 'a degree is usually a requirement for progression to the top levels of the profession and for professional chartership' (2009: 24). The survey respondents' aspirations to attend university, compared according to age range, are shown in Table 2.4. The disparity between sample sizes is particularly important here, where, for example, the 20% in the 20-29 age category represents two individuals. Nevertheless, it is interesting that a relatively high proportion of twenty- and thirty-year-olds indicate the desire to attend university. This chart combines two response options in the survey: 'go to university to study engineering' and 'go to university to study, but not engineering'. Respondents who indicated a preference for the latter, non-engineering, option included one 14-16 year old and three 17-19 year olds; none of the respondents in their twenties or thirties selected this option, indicating a more focused attitude toward their educational efforts.

Table 2.4 University aspirations, by age group



Of the total number of respondents expressing a preference to attend university (n = 28), 25 were male (89%) and 3 female (11%). This is in line with the gender ratios of the sample as a whole. Five respondents (18%) were apprentices. Eighty-six percent (n = 24) were teenagers, 7% were in their twenties (n = 2) and 7 % in their thirties (n = 2). Of this group:

- 32 % (n = 9) identified themselves as Black/Black British: African
- 14% (n = 4) identified themselves as Black/Black British: Caribbean
- 18% (n = 5) identified themselves as Other White
- 11% (n = 3) identified themselves as Other
- 7% (n = 2) identified themselves as Mixed White/Black African
- 7% (n = 2) identified themselves as White British
- 4% (n = 1) identified him/herself as Mixed White/Asian
- 4% (n = 1) identified him/herself as Mixed White/Black Caribbean.

Apprentices' after-course aspirations

There were 11 apprentices in the total sample of respondents: 9 male and 2 female; 5 White, 3 Black, 2 of mixed ethnicity and 1 Asian. This compares with the House of Commons Select Committee finding that nationally 'Only 2% of engineering apprentices are female and only 4% are black or an ethnic minority (BME)' (2008:102). In terms of ages, in this group there were:

- 4 between 14-16
- 4 between 17-19
- 1 in his or her twenties
- 2 in their thirties.

Apprentices were to be found in each of the course options, from the Specialist Diploma to the Level 3 NVQ and BTEC courses. Their responses to the question on after-course plans are worthy of note. Over half (n = 6) expressed a desire to go on to further study, with five of these individuals hoping to attend university (four in engineering and one in another subject) and one to study engineering to a higher level in college. Just under half of the apprentices (n = 5) indicated work-related plans after their course finished. The sample size is small, but this finding cuts against the assumption that apprentices are focused primarily on employment and tend not to have aspirations to tertiary education.

After-course aspirations to work, study and attend university, related to ethnicity

Respondents' after-course intentions, including a stated preference to attend university, were also analysed against the following categories of ethnicity:

- Black/Black British: African
- Black/Black British: Caribbean
- White British
- Other White.

The ethnic category in which students were most likely to express university aspirations was Black/Black British: African. Of the fifteen students in this group, 14 were male, one female. There was one apprentice. Thirteen respondents were in their teenage years, with one individual each in the 30-39 and 40-or-over categories. Of this group, 87% (n = 13) expressed study-related intentions after their course was over, with 27% (n = 4) hoping to study engineering further in college, and 60% (n = 9) hoping to go to university to study engineering. Two respondents (13%) hoped to find a job in engineering after their course ended.

There was a similar number of Black/Black British: Caribbean students (all male) completing the survey (n = 16). Twelve of these were teenagers, and four were in their twenties. There was one apprentice. Half of the respondents in this group indicated work-related plans, with 6 (38%) hoping to find a job in engineering and 2 (12%) to continue working in the sector. The other fifty percent expressed study-related intentions, with 4 (25%) hoping to pursue engineering studies further in college and 4 (25%) hoping to study engineering in university.

There were 25 students in the White British category, 23 males and 2 females. In this group 14 were teenagers, and 3 were in their twenties. Two were apprentices. Of this group 28% (n = 7) expressed study-related intentions, with most (n = 5) intending to remain in college and 2 individuals (8 % of the sample as a whole) hoping to attend university to study engineering. Sixty-four percent of this group expressed intentions to seek or remain in employment, with 8 hoping to find a job in engineering, 4 to continue working in engineering, two to continue in their role as apprentices, one continuing to work in a non-engineering occupation and one expressing a desire to 'own my own motorcycle business'.

For the purposes of this analysis, the single individual identifying as White Irish has been included in the Other White category, along with the other 10 individuals in this category. In this group 3 respondents expressed a desire to find a job in engineering after their course ended. Seven of the remaining 8 individuals wanted to continue their studies, with 2 intending to do so in college and 5 intending to go to university (4 in engineering, 1 in a different subject). One respondent was undecided on future aspirations.

Aspiration to further study, analysed by ethnicity, adjusted for age

Responses from these four ethnic groups were adjusted to filter out older students for whom aspiration to further study and especially to university becomes a less likely option. The future aspirations expressed by the remaining 80 students, aged between 14 and 29, were then compared by ethnicity. In fact, this group included 93 % of the students who indicated a preference to attend university, with the 2 individuals in their thirties who aspired to university being filtered out of the sample for this particular analysis.

The following charts show the proportion of individuals intending to pursue further study, compared to pursuing employment, in each ethnic group.

Figure 2.8 After-course aspirations: Black/Black British: African, 14-29

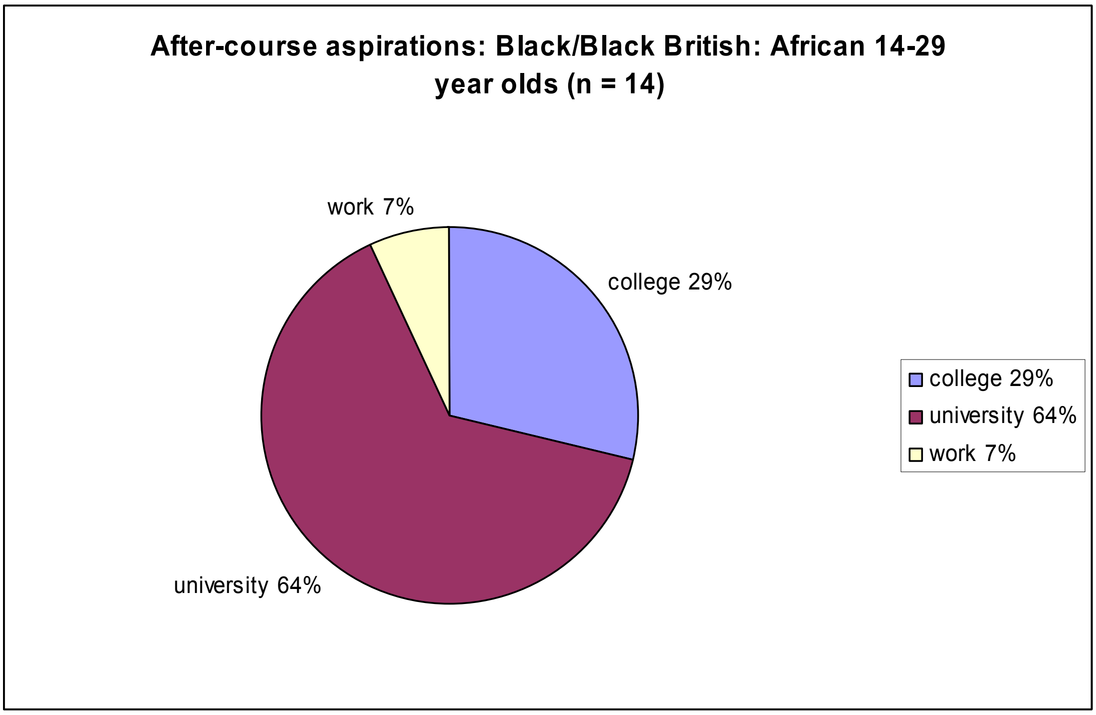


Figure 2.9 After-course aspirations: Black/Black British: Caribbean, 14-29

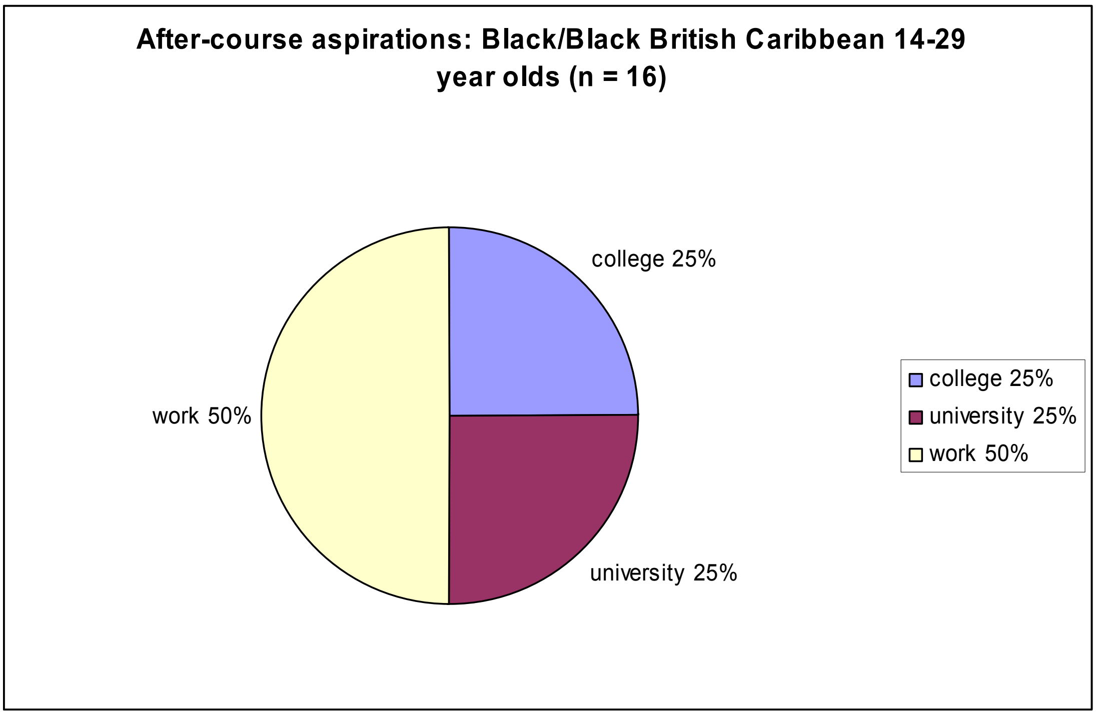


Figure 2.10 After-course aspirations: White British, 14-29

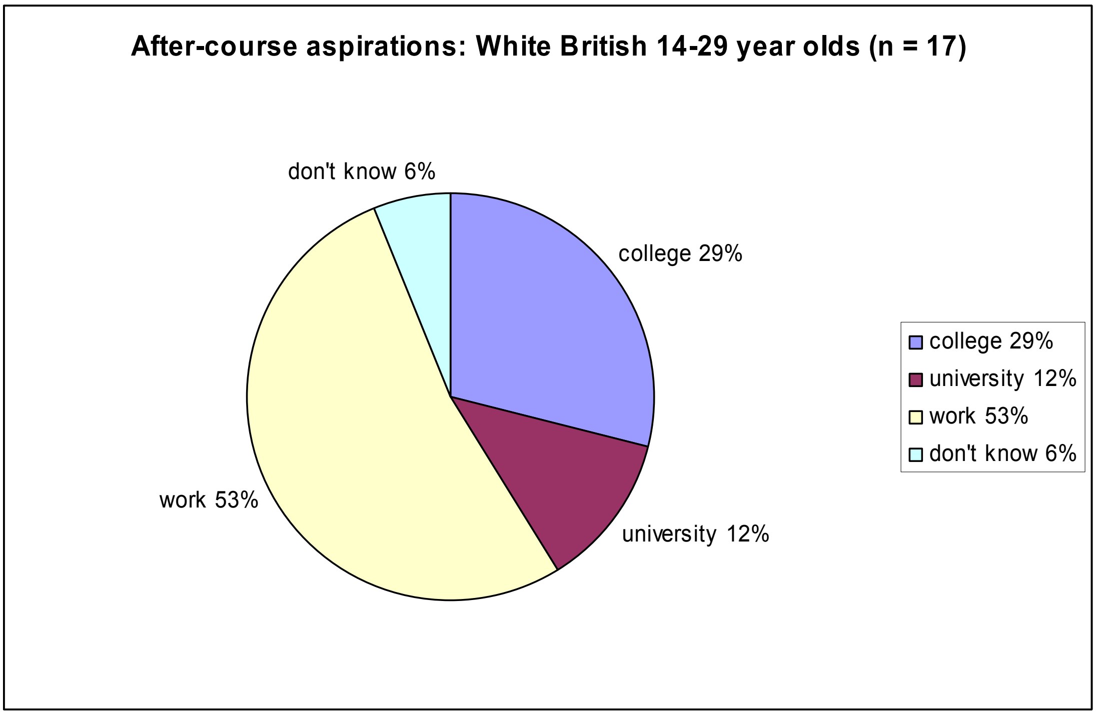
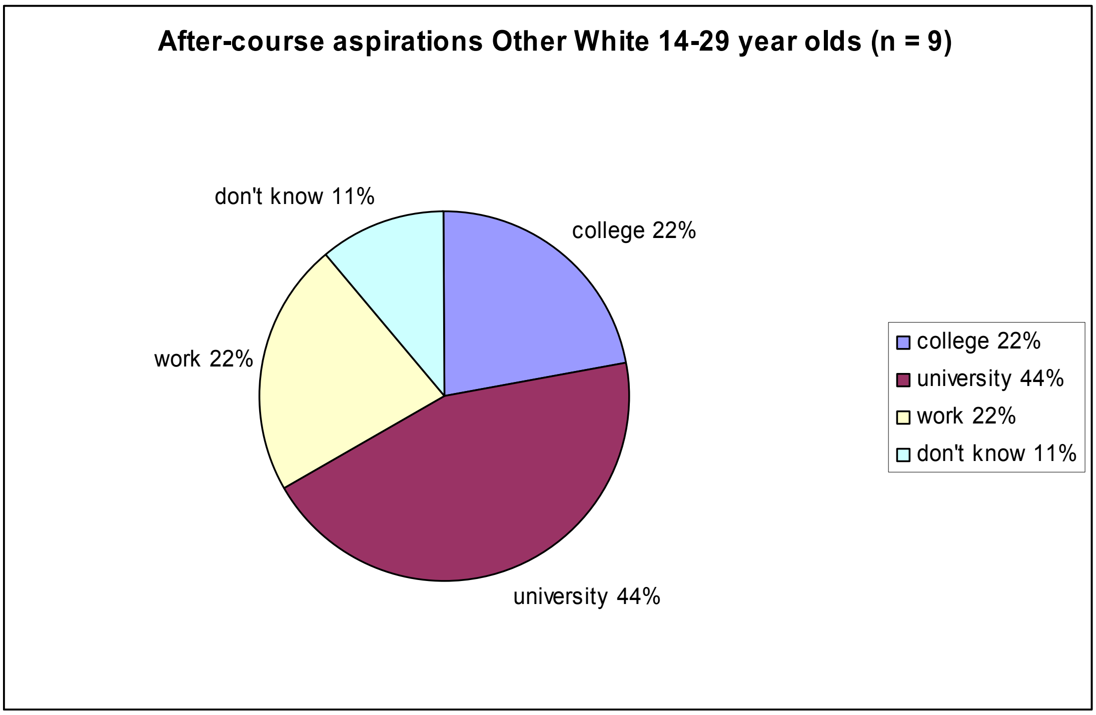


Figure 2.11 After-course aspirations: Other White, 14-29



As these charts indicate, considerable differences among ethnic categories emerge when the proportion of students indicating aspirations to study further, and especially to study at university, are compared with their intentions to enter or continue in the workforce. Again, these findings must be interpreted with caution, due to small sample sizes. Nevertheless, the striking finding emerging from these comparisons is the variance in university aspirations among the different ethnic groups. Black/Black British: African students in their teens and twenties overwhelmingly indicated a preference for further study (13 out of 14, or 93%), with over two-thirds of this group expressing a desire to study at university. The next largest expressed preference for further study (66%) came from the Other Whites category (which incorporated the single White Irish student). Two out of three students in this category expressed a desire to study at university, with one third selecting the option 'study engineering to a higher level in college.' Black/Black British: Caribbean students indicated the next highest preference for study, with half choosing this option and half choosing employment. The 50% who wished to continue studying were evenly divided between those preferring university and those preferring to continue in college. The lowest preference for further study of any type was expressed by White British students (41%). Only two individuals in the White British category of 14-29 year-olds (12%) expressed the intention to study engineering in university, with five (29%) intending to study engineering further in college.

After-course aspirations relative to gender

As noted above, 10% of the respondent group were female (n = 9). Engineering bodies such as the Royal Academy of Engineering, as well as educators and professionals in the field, are concerned with the low rates of female students on engineering courses and entering the profession. The House of Commons Select Committee reported that only 2% of engineering apprentices, 14% of engineering undergraduates, and just over 6% of professional engineers are female (2008: 102-3). So it is worth analysing this group separately. All of the female students in the respondent group were teenagers, 5 between 14 and 16 and 4 between 17 and 19. Two were apprentices. There was a mix of ethnic identifications in the Black, White, Mixed and Other categories. Four were studying for the Specialist Diploma in Engineering and the others were spread among Level 1, 2 and 3 courses. Of the eight students answering the question about after-course preferences, three wanted to continue working, either in engineering-related jobs (2) or in other jobs (1). Neither of the apprentices chose the option stating that they wanted to ‘continue working as an apprentice’. Five students (ie just over half) wanted to continue studying engineering, 2 to a higher level in college and 3 in university.

The proportion of female students – just over half – hoping to go on to further study either in college or university, is in line with the 61% of 14-29 year-olds in the total sample expressing this preference. The proportion of female students expressing a desire to attend university was identical to the proportion of university aspirants in the total group of 14-29 year-olds (one-third of students in both cases).

After-course aspirations relative to college course

The students’ responses as to their future plans were further analysed in terms of the types of course they were undertaking. Overall, students’ responses in these categories tended to replicate the age-related responses, with higher proportions of younger students wanting to remain in education and more older students wanting to move into or remain in employment.

Specialist Diploma in Engineering students

Of the 14 Specialist Diploma students completing the survey (9 male, 4 female, 1 not specified), 4 indicated they would like to study engineering to a higher level in the college, while 5 responded that they would like to study engineering in university. One said he or she would like to go to university, but not to study engineering. One respondent intended to find a job in engineering, and three to ‘continue working in engineering’ (this question was possibly misunderstood as meaning continued study, as none of the respondents answered on a different question that they had had work experience or employment in engineering.) Of the 14 secondary students responding, at least 10 were looking to continue in education.

Level 1 NVQ students

The aspirations of students of similar age on Level 1 vocational FE courses in the college were remarkably similar. In both groups, over 70% expressed the intention to continue in education. The sixteen students on Level 1 NVQ Engineering courses were all teenagers, 8 between 14 and 16, and 8 between 17 and 19 years old. Two of them were apprentices. Fourteen were male and 2 female. Of this group, 7 intended to continue their studies in engineering within the college, and 4 wanted to study engineering in university. One intended to study at university, but not in engineering. Three intended to find a job in engineering and one to continue working in a job outside engineering.

Level 2 NVQ students

Students on Level 2 NVQ Engineering courses were one of the most varied groups in terms of age. Of the thirty respondents, 18 were teenagers (60%), and at least 4 of these were talented students on the Specialist Diploma. Three respondents were in their twenties (10%) and 9 were in their thirties or older (30%). There was one female respondent in this group. Unsurprisingly, aspirations were also more varied in this group, with nearly half (14) intending to find, or continue in, employment after their course. Six respondents wanted to continue studying engineering in college, and 7 to study engineering in university. One intended to go to university, but not in engineering.

Level 3 NVQ students

Students on the Level 3 NVQ course had a roughly similar age profile to the Level 2 NVQ students. Of the 14 participants, half were between 14 and 19, 3 were in their twenties and 4 were thirty or over. All respondents were male; three were apprentices. In this group, employment featured more largely in respondents' after-course plans, with two out of three participants (n = 9) indicating employment-related intentions. Six of these students wanted to find an engineering job, one to continue as an apprentice, and two to move into running their own motor-related businesses. Of the 5 students hoping to go to university, 4 wanted to study engineering. One of the students expressing a preference to go to university was in his thirties.

Level 3 BTEC National Diploma students

The sample size for the BTEC students is considerably smaller: six students, all male, one apprentice. Five were between 14 and 19 years old, and one in his twenties. In this group, 2 respondents indicated employment-related plans, one to find a job in engineering and one to continue as an apprentice. Four students intended to continue studying engineering, two at a higher level in the college, and two in university. Although the very small sample means these results are not generalisable, nevertheless, they may be indicative. This group of Level 3 students had a slightly higher level of previous qualifications than students on other courses, and the three FE students selected by college lecturers for interview on the basis of their talent for engineering, were all studying on this course. This is in line with the rigorous demands and standards of this qualification.

'Engineering Access' course students

Three students indicated that they were 'doing an Engineering Access course at Lambeth College'. These students were all male, one aged 17 to 19 and the other two in their twenties. One was an apprentice. While the 'Access course' response option in the survey was intended to relate to the college's one-year, Level 3 course providing access to university, the respondents who selected this option were taking the college's pre-Level 1 'entry' programmes in numeracy or literacy, in preparation for entering college courses in the future. (The university Access course students evidently did not participate in the survey, possibly because it was administered when they were at university.) None of the studentsselecting this option indicated a preference for studying engineering (or another subject) in university. One wanted to study engineering to a higher level in college, and the other two wanted to find a job in engineering or continue working in engineering.

In sum, younger students tended to express a preference for continuing in education, whether they were studying for the Specialist Diploma or for vocational qualifications. Students studying at higher levels (a group that included students in their 30s and older – nearly one-third of both the Level 2 and Level 3 NVQ courses) tended to be more focused on work-related plans. Proportions of students in each course expressing an interest in attending university included:

- 43% of Specialist Diploma students
- 36% of Level 1 NVQ students
- 26 % of Level 2 NVQ students
- 36% of Level 3 NVQ students
- 33% of Level 3 BTEC National Diploma students

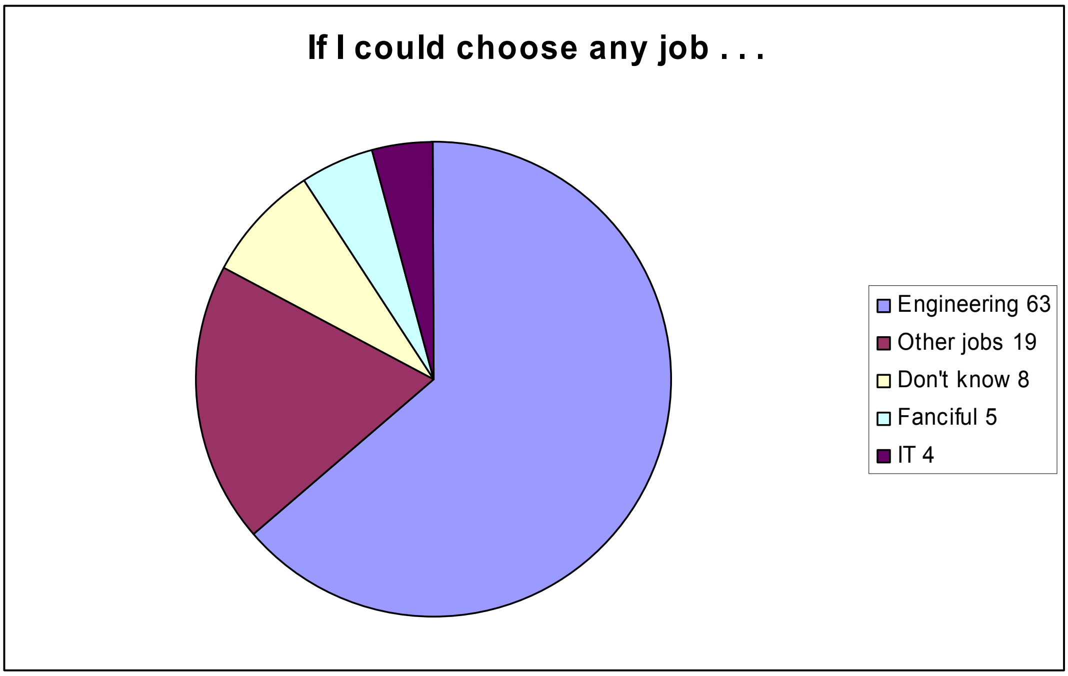
An interesting aspect of these findings is the relatively high proportion of students on each course expressing a preference for university study: one-third or over for each course except the Level 2 NVQ group, where one quarter of students were looking toward university.

Participants' ideal jobs

As a final gauge of interests and aspirations, the last question of the survey invited participants to complete the open-ended prompt: 'If I could choose any job, I would most like to …:' The analysis of responses is shown in Figure 12. Of the 81 responses given, 63% (n = 51) related to engineering occupations in the widest sense, including automotive-related, electrical and electronic, IT and sound engineering, and aeronautics. Again, this is not surprising, given the context in which students completed the survey. A substantial proportion of these responses were automotive and motorcycle-related (26%; n = 21), reflecting the motorcycle repair course that many of the participants were undertaking.

Nineteen percent of participants (n = 15) mentioned specific occupations, such as working in the police, military or prison service, architect, pilot, locksmith, electrician, scientist or entrepreneur. Five percent (n = 4) gave fanciful responses, (such as 'lager tester', 'be Jeremy Clarkson') and 8 % returned 'Don't know' or irrelevant answers. Three respondents (4%) mentioned non-engineering IT-related jobs such as web designer. Across several of the main categories, 6% of respondents used the word or concept 'design' (eg architect, web designer, 'involved in the motorcycle design process'). It is interesting to note that both of the students giving their ideal job as 'architect' were female.

Figure 2.12 If I could choose any job, I would most like to:



Summary

Approximately three-quarters of the 94 students surveyed were between 14 and 19 years old; 85% were aged 14 to 29. Nine out of ten were male. In terms of ethnicity, just under 40% self-identified in various categories of Black, with the same proportion identifying in various White categories. The survey invited responses in the areas of students' learning preferences, motivation, sources of support and aspirations.

The notable finding regarding students' likes, dislikes, and self-reported strengths and weaknesses, is the high proportion who liked and considered themselves best at the practical, 'hands-on' aspects of engineering. Although two-thirds of students rated themselves best at practical aspects of their courses, slightly less than half reported that they liked these aspects best, with answers indicating enthusiasm for the satisfaction of learning and for all aspects of the course also figuring in responses. Writing was cited as the aspect students liked least (22%) and, after Maths, as the part most students considered to be their weakest area (14%). Nearly 20% stated that there was nothing on the course that they were 'worst' at.

Given the importance of Maths as an underpinning for engineering, it is worth noting students' attitudes toward this subject. Two percent of students identified maths as 'the part of engineering I like best' while 10% cited it as 'the part of engineering I like least'. Six percent reported that maths is 'the part of the course I am best at', while 15% gave it as their main weakness.

In reporting on their motivation for undertaking their engineering courses, nine out of ten students ranked intrinsic issues such as liking practical, hands-on work and knowing how things work as their prime motivators. This is the most unequivocal result emerging from the survey. In terms of encouragement from others to undertake the course, students ranked their family members most highly. Nearly half of students reported that when they needed help in understanding difficult aspects of their course, their teachers' help was most important, with nearly a quarter ranking 'figuring it out by myself' as their first or second choice. This highlights the vital role of teachers in a demanding technical subject (perhaps especially important in an area with high levels of social disadvantage), but also attests to learners' awareness of the need for individual effort to master difficult content.

Key findings with regard to students' reported future intentions include:

- the high proportion of apprentices (45%) who aspired to attend university, a finding very much at variance with recent reported trends in this area
- the high percentage of Black/Black British African 14 to 29 year olds who expressed a preference to pursue further studies, either at college or university (93%)
- the high proportion of Black/Black British Africans in this age group who aspired to attend university (64%)
- In this age group, the ethnic category with the lowest expressed preference to attend university was that of White British students at 12%. This compares with 44% of students from Other White backgrounds, and 25% of Black/Black British Caribbean respondents.

Section 3: Findings from the interviews with students and teachers

To acquire a more nuanced understanding of key issues in the learning preferences, aspirations, sources of support and trajectories of engineering students, case study interviews were conducted with:

- 4 secondary students studying on the Engineering Specialist Diploma
- 3 FE students undertaking Level 3 vocational engineering courses
- 3 university students doing university Access degrees in engineering.

Teachers' perspectives were ascertained through case study interviews with:

- 1 secondary teacher on the Engineering Specialist Diploma
- 3 FE engineering lecturers
- 2 university lecturers teaching on the Access course in engineering.

Interviews with the secondary and FE students and teachers took place at the host FE college, and those with the university students and teachers at the host university. Informed consent was obtained from all participants, and, in the case of the secondary students, from their parents or guardians. Interviews were audio taped, with notes taken from the recordings. Notes from the interviews with the teachers were sent to the interviewees to check for accuracy and correct interpretations. In the following account, all interviewees have been given different names to preserve anonymity.

This section has been divided into two parts:
Part One: The view from the college
Part Two: The view from the university.

Part One: The view from the college

Secondary students

The secondary students attended a nearby school with a specialism in technology, judged by the most recent Ofsted report to be ‘good with outstanding features’. The school, located in the same disadvantaged borough as the college, has a high proportion of young people with dislocated backgrounds for a variety of reasons. The students were 14 or 15 years old, and in the first year of the Specialist Diploma in Engineering. Because of their ability in the subject, for their work in the college they had been moved from the main Specialist Diploma class into the more advanced Level 2 NVQ course. The FE college was in partnership with the school to teach the programme, and had been recently equipped with a specially refurbished teaching room specifically to accommodate the Specialist Diploma teaching. Lecturers at the college had ensured that the learning space had appropriate CAD-CAM computer equipment, software and workstations. The secondary students attended the college every Friday for lessons with the FE lecturers. The engineering teacher from their school frequently called in to the college on a Friday to see how the group was getting on, although this was not part of the formal arrangement. The FE lecturers appreciated these discretionary, trouble-shooting visits, which helped make the partnership work effectively.

The secondary students were in the enviable position of benefiting from funding for the pilot year of the Engineering Diploma, and from the well-supported London Engineering Project, which ran enrichment events for students and development opportunities for teachers. In addition, they had the rare benefit of a classroom teacher with a degree in engineering and experience working in industry. Both anecdotal evidence from secondary schools and the findings of the 2009 National Grid *Engineering the Future* report reveal a scarcity of specifically-trained engineering teachers for the new Specialist Diploma (p. 24). Frequently, non-specialist teachers from the sciences or Design and Technology are called upon instead.

In the college, the secondary students benefited from the new state-of-the-art teaching room, from the experience and skills of FE lecturers who had engineering backgrounds, from the college’s engineering technicians, and from the presence of Learning Support Assistants (LSAs). LSAs tend to be virtually unknown in the FE sector because of budgetary constraints, but they are a requirement for teaching compulsory-phase students. The FE lecturers had used this requirement to create synergies between the younger, school-aged students and older, vocational students, by employing talented BTEC students as LSAs. The FE lecturers had previous experience of teaching school-age students through their engagement with the college’s School Links programme, part of the Increased Flexibility initiative (Harkin 2005).

The secondary students interviewed by the research team were nominated by the FE teachers for their talent in engineering. Interestingly, these students had all been moved from the normal Specialist Diploma classes to Level 2 NVQ (ie *vocational*) courses to provide them with a higher level of cognitive challenge. Interviews took place in March 2009, in quiet classrooms in the college during one of the students’ regular weekly visits.

In the interviews, the students' views were elicited as to:
- their attitudes to the subject of engineering
- what they find helpful in learning engineering
- sources of support for their learning
- their plans and aspirations
- advice for schools, teachers, and families in how to support learners like them.

Interview questions for the secondary and FE students appear in Appendix 2.

In two cases, the students' interview responses were compared with their responses to the online survey, to establish patterns or inconsistencies. One of the students did not give permission for this to happen, and one had not done the survey (presumably due to absence on the day it was administered), so there was no survey response from him to compare. The other two students explicitly gave their permission for the researchers to consult their survey responses (located via their student number).

Charmaine

Charmaine is a 15-year-old white British girl and the only female student among the college interviewees. (There were 5 girls, including Charmaine, among the Specialist Diploma students who completed the online survey.) By the time she reached Year 10, Charmaine had been to nine different schools in various parts of Britain. At home, the fact that her step-father is an electrician who sometimes lets her accompany him when he wires houses, has positively influenced her. Charmaine is a lively all-rounder who will take early entry for English, maths and science at GCSE. She also enjoys playing sport and is taking dance classes, about which she is enthusiastic. She was training to be a dance teacher, although she had only taken up dance within the past year. She said she was uncertain about whether to try for engineering – mechanical or electrical; dance; or maybe even hairdressing.

Charmaine is an example of a talented secondary school girl interested in engineering, whom the profession and the UK government is hoping to prevent from 'falling through the cracks'. Philip Greenish, Chief Executive of the Royal Academy of Engineering, commenting on diversity issues in general, reported to the House of Commons Select Committee, '[W]e need to work really hard to understand how interventions at different stages of a young person's life actually make an effect in terms of their decisions and where they end up at the end.' Terry Marsh of Women into Science and Engineering (WISE), called for more research into the life choices and influences on potential women engineers, '[W]e do not have good solid evidence as to what it is that is affecting girls and their decisions in life. Is it their peers, is it the media, is it their parents, is it teachers?' (House of Commons 2009: 103).

Tommy

Tommy is a 15-year-old black boy with a confident and sunny disposition. Tommy did not complete the online survey, so his specific category of Black ethnicity was not established. He has lived in London for 7 or 8 years. Tommy spoke with enthusiasm about engineering as the foundation of many key aspects of daily life: 'I knew that everything around had to be engineered and made, so I figured I wanted to be a part of that one day.'

Robert

Robert is a rather quiet, 14-year-old boy of African origin, who needed much prompting to elicit answers from. He did not agree to his online survey responses being used in the study. Robert likes school and college and is, by his own estimate, a student who is good at maths and science, in which he does well. His ambition is to become a doctor (or engineer, he added, somewhat politely). He was the only student in this Level 2 engineering cohort to pass all three functional skills assessments.

Carlos
Carlos is a confident, 15-year-old boy with a self-professed talent for maths, science and practical projects. He came to London from a South American country at the age of three and still speaks Spanish at home. He receives a lot of support and encouragement from his mother, with whom he discusses his aspirations. He wants to go to university and to become an entrepreneur, possibly linked to engineering, in order to help his family. Carlos appears mature beyond his years; the term 'responsibility' occurred several times in his interview as something he takes seriously.

Attitudes to engineering
Charmaine was persuaded to take the college-based Level 2 engineering course by her school teacher of Resistant Materials. She decided that taking the course would be 'something I would enjoy' and 'something that would affect my future'. Carlos had ambitions to be an entrepreneur and Robert seems to be more interested in engineering's links with scientific subjects. Tommy wants to be an automotive engineer, and had thought about the wider international possibilities of working in engineering: 'Engineering happens all over the world, so you have to study languages.'

In keeping with the overwhelming enthusiasm for practical work revealed in the online survey, all of the secondary students enjoyed this aspect of their engineering course. (Both Carlos and Charmaine selected liking 'practical, hands-on work' as their first reason for choosing the course.) In the interview Carlos rated some elements, such as soldering, as somewhat difficult, at least initially, and expressed impatience with all the health and safety rules and practices.

Charmaine found maths the most challenging part of the curriculum. 'Measuring things and making it precise is difficult. None of us [students] have a clue about calculations. Sometimes I complain it's really difficult.' Carlos, Tommy, and Robert liked maths and said they found it easy. Robert found most of the course content easy except electronics. Carlos found Ohms law difficult, which may be an indicator of reluctance or difficulty in engaging with theoretical concepts as distinct from more practical activity (again, a recurrent theme in the online survey results). Tommy found some of the ICT elements, such as recalling formulae in Excel, difficult, although this appeared to be a procedural rather than conceptual issue. Tommy and Charmaine found writing up their work tedious but not difficult.

What students find helpful for learning engineering
All of the students mentioned liking their teachers and the course, and finding teachers' and learning assistants' help very useful. As Tommy noted, 'The teachers teach you in a way that you understand.' Carlos liked coming to the college: 'There's so many things to do, and you learn more every single time you come…it's like a different environment to school…You feel like you have more responsibilities.'

The students were asked what experiences from primary school had contributed to their interest in engineering. Robert felt that doing experiments had been helpful. Carlos couldn't think of anything from primary school that spurred his interest. Charmaine mentioned building a model bridge and testing it to see how much weight it would support. Tommy had been enthused by work in geometry and made links between this and his interest in design and engineering: 'Shapes. Yeah, I liked shapes. Take a look at houses and all that. It's like square, and some of them have that triangle at the top…It's just different shapes.'

The students reported that earlier in secondary school they found subjects like Design and Technology and Resistant Materials helpful in promoting their interest in engineering. The 'doing' aspects of these subjects, such as projects, product design and even sawing, were attractive. As Carlos said, 'I like making things,,, [you can] take them home, put them on a shelf.'

Charmaine reported being well-supported at school in a range of practical subjects, including Art and Design and Technology. The school had organised residential trips to places such as Thorpe Park to see how the rides are constructed, and to Portsmouth University for a four-day residential course during which the students worked, fairly independently, on engineering projects.

Sources of support
Carlos, Charmaine and Tommy all appeared to be well-supported by their families in various aspects of their schoolwork, with Robert perhaps less so. Carlos indicated a high level of emotional support from his mother: 'My mum said, if you want to do something you should go ahead with it. She encouraged me a lot.' She protected his study environment at home, but was unable to help him with the content of his work. Carlos also has a friend who was an engineer in his native country: 'He helped me quite a lot.' Charmaine could ask her mother and step-father, who is an electrician, for help with homework, and also phoned friends for help.

Neither Robert nor Tommy had family in engineering, but both had e-mentors, organised by the school through the Brightside Trust's LiveJournals programme. Tommy said, 'I don't have any family in engineering, but there's this Internet site thingy which gets you to talk to actual engineers. They've actually worked in the engineering profession.'

All of the students felt their teachers and learning support assistants were helpful in their studies. In the online survey, both Charmaine and Carlos ranked 'figuring it out by myself' as most important when they needed to understand something hard on their course, indicating a high level of self-motivation for their learning.

Plans and aspirations
Both Carlos and Tommy specifically mentioned their intentions to attend university. Afterwards Carlos wants to 'start my own little business to do with engineering' and Tommy hopes to be an automotive engineer. Robert's plans were vaguer, but involved 'something to do with science, like a doctor, or maybe an engineer.' He thought he might ask his e-mentor about the qualifications needed to continue with engineering. Charmaine is undecided about what to do later in life – she toyed with the idea of becoming an architect but the seven years of training required put her off. She thought she might pursue dance, or hairdressing, but is also thinking about following engineering in some way, but whether mechanical or electrical she does not know.

Advice to teachers, schools and families
Carlos felt that the school 'could get more equipment and get the teachers to know more about what they are doing. They could have more teachers to do with engineering because at the moment there is only one teacher.' He felt that some students didn't get sufficient attention from teachers and added, 'I think that a teacher should pay more attention to students that are good to make them better.' Some of his fellow students were distracting because they talk and are disruptive in class.

Robert thought more extra curricular activities and after-school clubs would be more helpful, despite the secondary teacher's observation that, during the pilot year of the Diploma there was almost too much on offer in terms of enrichment provision through, for example, the London Engineering Project.

In terms of family support, Charmaine thought that help with revision would be a good thing. Tommy thought that parents could help young people in engineering through encouragement because 'it really makes the child feel good and want to do it more. When your parents want you to do something, you think, "Yeah, maybe I might do that".'

Further Education students

The college tutors nominated 3 talented students on the BTEC National Diploma Level 3 course, who, for the purpose of this study, are called Antony, Mike and Paul. Antony and Mike completed the online survey and gave permission for the researchers to use it in the study. Paul did not do the survey, presumably being absent that day. Interviews with the FE students took place at the college on the same day as the interviews with secondary students.

Antony
Antony is a 16-year-old boy of Black Caribbean heritage who has lived in London 'for a while'. He's in his first year of the Level 3 BTEC National Diploma in Electronics and Communications. Before his BTEC course, he had attended the college one day a week since he was 14, on the School Links programme. This was a key motivating factor in his decision to study engineering further. 'Doing the School Links course, I quite liked the course, and it was quite practical and I thought, I want to further my skills. I could see that I had potential because I was getting merits and distinctions. So I thought, this is the sector I liked and I decided to do the BTEC National Diploma.'

Mike
Mike is 19 and originally from Jamaica. He finished school there, achieving a CXC (Caribbean Examination Council) award (a secondary school leaving award equivalent to the GCSE). He then came to London, where he's been living for about 2 years. In that time he has been attending the college, and completed the BTEC First Diploma. His FE tutor informed the researcher with avuncular pride that Mike had received distinctions in 6 out of the 6 modules of this course. Mike said modestly. 'I like the practical, and I like electronic stuff, so I kind of enjoyed it.'

Paul
Paul is 17 years old and in his first year of a BTEC National Diploma in electronic communication. Paul is white, but as he didn't do the online survey, it is unclear which white sub-group he would have specified. He has lived in London for about 8 years and attended the college for a year or two on the School Link programme. He started his BTEC course because 'It sounded interesting… and I liked doing Resistant Materials in school, so I thought I'd try and see what it was like.' Paul has a bent for programming and likes the computer-related aspects of the course.

Attitudes to engineering
Like the secondary students, the FE students showed a high level of intrinsic interest in their engineering courses. In his response to the online survey, Mike ranked 'I like practical, hands-on work' first, and 'I like problem-solving' second, placing 'It will help me get a job' sixth out of seven. Mike had done electronics back at school in

Jamaica, 'I really liked it…trying to see how stuff works and trying to solve problems.' Antony ranked the option 'It will help me get a job' first, and 'I like practical, hands-on work' as fifth (with no other choices in between). Paul liked doing Resistant Materials in school and enjoyed 'the programming side of [his course], which is what I'm strong at'.

In terms of aspects they found challenging or didn't like, the students cited maths and theory (again reflecting the majority view in the online survey results). Antony cited 'the majority of the theory' as something he both didn't like and found hard, explaining 'you [ie teachers] can't really show it that much, so it's kind of hard to take in, so you [students] have to make sure that you have 100% attention throughout the lesson…Sitting through lessons that are theory…gets kind of boring after a while . .. and my attention span goes haywire.' He contrasted this with practicals: 'When you're doing a practical basically you have 100% attention on your practical work so you know what you're doing and you're able to take it in more….So I like to have the practical to keep my attention span the highest it can be.' Paul mentioned 'the maths section of it' as the hardest aspect, but admitted he needed to put in a lot of effort in this area: 'I don't think I'm very good at maths, I'm alright, I can do certain stuff, but I just have to carry on going through it, otherwise I just lose it.' Mike found digital electronics 'not all that difficult, but sometimes kind of challenging…But if I apply myself to it more I know I will get it. So I just need to spend more time studying it.'

What students find helpful for learning engineering

Each of the FE students volunteered information about how much they liked the practical aspects of the course, and emphasised that this is crucial to their learning. Antony specified practical work when asked about both what he liked best and what he was best at. He finds the easiest part of the course to be 'doing practical work because it makes me understand the work more…When it's in front of me I can actually see what's going on, and it makes me understand the course more easier.' This was also the case for Paul. Paul tended to be rather noncommittal in the interview, but became more forthcoming when asked what kinds of things helped him learn. 'Actually getting to do it instead of just listening to it…I'd do better if I tried it myself instead of just listening to someone talk about it…I'll just sit there and not understand it until I actually do it…'cause it's just a bunch of letters on a board. It's the way I learn, I think.' Mike found practical things like building circuits and soldering easy: 'I like those a lot.'

Both Paul and Antony mentioned the help from both teachers and tutors in keeping them focused on their termly learning targets, which were reviewed around the middle of each term. They also have weekly tutor periods.

The students were all aware of their own responsibility for their learning, with Paul and Antony mentioning the need to listen attentively to explanations. Antony: 'You have to make sure that you have 100% attention throughout the lesson.' Paul: 'Obviously if you're not going to pay attention, you're not going to get anything really.'

Mike seemed particularly self-motivated. On the day of the interview, he had no classes at college, but had come in to use the library. He said he enjoyed researching into electronics as it 'gives us a wider range to understand how things work' For this, he consults the internet and 'I use a lot of books.' He also took advantage of a weekly voluntary engineering workshop, with a teacher and technician present, where students can work on their own projects. 'If we're behind in class, we can use that Wednesday evening to catch up, and accomplish what we need to be finishing.' His motivation and seriousness about his work, as well as his obvious ability and high marks, were reasons his teachers had nominated him as a talented student to be interviewed.

Antony would have appreciated more reiteration of content, commenting that he would find it helpful to have verbal summaries of previous weeks' key points at the start of each class.

Sources of support
Like the secondary students, the FE students spoke warmly of the help they received from their teachers and tutors. Antony said, 'The college tutor is there for being able to talk to…and mak[ing] sure we're doing good on the course.' Mike said, 'They don't actually give us the answers but they will let us know where to look, and motivate us and tell us to keep going.' [How do they motivate you?] 'They give you an encouraging word and if you do your work and show them they smile and say. "That's really nice, man." …You get feedback…Even if [your work is] wrong, they'll actually say, "It's kind of all right, but you can change that bit…"' Mike also mentioned getting help from the learning support staff at the college, for example with mastering software packages.

In terms of support outside the college, all of the students had family or friends whose support they found helpful. Antony's father 'has some experience in the sector, so he does help me with certain stuff, so that's an advantage for me, and I like that he's there for me.' Mike has an uncle who works in electronics, 'but he's not really in this country'. However, he did benefit as a child from watching his father repair things at home: 'My dad always come fixing stuff, so I could pull out a radio and look around in it.' Paul, the most self-contained of the interviewees, enjoyed doing 'different types of programming at home like HTML and stuff but nothing related to this….I have a friend who does computer engineering, and obviously he knows what I'm studying now so I could refer to him if I needed any advice…but I haven't.'

Plans and aspirations
All three of the FE students expressed intentions to attend university. In the online survey, both Mike and Antony selected 'go to university to study engineering' as their preferred next step after the BTEC course. Indeed, in the interview, Antony said he was thinking beyond a first degree to postgraduate work in engineering. 'The plans that I have is to go to university and to do … a degree in electrical and electronics engineering, and after that … I maybe want to go and get a Masters, and then maybe go into industry or maybe teaching, and maybe later on, go for a PhD.' This positive attitude toward university seemed directly related to his familiarity with and previous good experiences in a university environment. At school he had participated in an enrichment programme based in a London university where he 'used to have, like, extra lessons, and do like critical thinking skills, maths, and things like that… They made me feel welcome in the university so I'd like to go there again.'

Mike, at 19, also appeared to have focused plans and was starting to think seriously about looking around at universities. He wanted to 'go to university and study computer system engineering. I have one more year at college. I definitely want to go to university after this.' Paul said he was 'thinking of working and going to university at the same time, but I'm not actually sure yet, not really 100% sure that's what I want to do.'

Advice to teachers, schools and families
When asked about what secondary schools might do to help students learn engineering, Paul suggested that more assessed group work, like the group projects

in his course in college, would be helpful. His reply appeared to refer both to real-world relevance and to educational progression issues: ‘Group small projects which could give you a grade at the end, I suppose … toward your GCSEs.’ Such projects could focus on ‘what we would encounter in college, [because] in college we do what we’d encounter in the real world…It would help if we got an idea what happens in college.’ Antony would have liked more integration in secondary school between his in-school work toward GCSEs and his work in college ‘because when I went on the School Links I had to miss out on half of a GCSE, so I [only] had half of the lessons of the GCSE and that required me to catch up in my own time.’ (This issue may be less of a problem with the introduction of the Specialist Diploma award.) Mike felt he had benefited from attending a secondary school in Jamaica with a specifically technical focus. ‘It was more of a technical school. So it have a technical bit and I usually study electronics there, so it really get me going and I really like it from them times.’

In terms of the sources of support the FE students wanted to help them plan the next stages of their education, Antony wanted information. ‘What I’d like to know is what types of jobs I can go into, and … what qualifications I needed like for a certain degree, and where it could take me later on in life.’ Mike specified information about universities, including information on courses and on what the university environment was like. Compared to Antony, who had experienced the HE environment already, Mike appeared to have some underlying anxiety about what to expect from the unknown world of university. He would like ‘motivational speeches, so other people who have been there can come back and talk to us and give us their experiences so we actually know what to expect. Maybe sometime we can even relate to their experience… and we can say “If they can do it then we can do it.”’ Antony also reiterated the usefulness of visits, both from school (‘taking schoolkids to university, or college…giving them an insight’) and from home, suggesting that parents could ‘take people to places that involve engineering to get some insight into how it is… to meet [engineers], to decide whether to go into it or not.’

Paul was less forthcoming than the other two students and sounded a bit disenchanted about family support. ‘I guess most parents should be interested in what their children are learning, but most really don’t care.’ To ‘motivate us’ they could ‘just look at what their children are doing in college, and drive them towards a good grade.’

The secondary teacher

A striking, and indeed frustrating, aspect of organising the interviews was the difficulty in finding participants among secondary teachers. It did not prove possible to find more than one secondary teacher for interview, despite repeated attempts to identify additional interviewees through appeals to personal contacts of the teacher, college lecturers, neighbouring schools teaching the Engineering Specialist Diploma in the borough, and the Brightside Trust, the charity administering the engineering e-mentoring facility for the London Engineering Project. Given the shortage of specialist engineering teachers in secondary schools (National Grid 2009: 24), this is perhaps unsurprising. Tariq, the teacher who agreed to be interviewed, was unusual in having an engineering degree and experience in industry. He was the liaison for the Engineering Specialist Diploma between the school and the college, and was interviewed at the college.

Tariq

Tariq has been teaching in the local technology school for the past 5 years. This is his first teaching post. Previously he completed a degree in engineering and worked in industry for about ten years before training to teach. His background is in machine tools and heavy engineering equipment. He spent 6 years in a design office. This experience, he says, gave him ‘a different vision to what I had when I was at school. I thought you just draw. It’s considerably different now, there’s a lot of CAD-CAM involved and you have to use that as a tool… I know what’s required and the standard at which [engineers] have to work. I work to British standards and that way, when [my students] go out into the real world, they know what’s required of them.’

The FE lecturers

Richard
Richard is the liaison tutor in the college for the Specialist Diploma in Engineering, and also teaches on a range of other courses, including the School Links programme, and Level 2 and 3 BTEC courses in Engineering and in Electronics and Communications, as well as the college’s Level 3 HE Access course in Engineering. He has worked at the college for 10 years. Previous to that he completed an Access course at a London FE college, and earned a Higher National Diploma and a degree in engineering at a London university. He then worked in industry before coming to teach at the college, where he has completed a PGCE, and City & Guilds Assessor’s and Verifier’s Awards.

Phil
Phil has been working at the college full-time for 11 years, and had worked there part-time for several years before that. After he left school, Phil worked as a vehicle engineering apprentice in the motor industry. Then he moved to a London FE college which was setting up a large multi-skills centre that included a motor vehicle workshop. This college paid for him to train in electronics, and he earned a series of vocational qualifications from City & Guilds Level 1 up to a Higher National Certificate at a London university. He is now an Advanced Teaching Practitioner at the host college and oversees its university Access course in Engineering.

Ed
Ed has worked at the college for 6 years and teaches on a range of courses, including motorcycle service and repair with a variety of students. He also teaches on the School Links programme and 14-19 programmes, as well as working with adults. He teaches on courses leading to the Institute of Motor Industry (IMI) awards for Levels 1, 2 and 3. Early in his career Ed worked in motor and aeroplane mechanics in the army, then in the motorcycle industry from 1968. He was recruited into the college from that industry by the Head of College, starting as an advisor on motorcycle mechanics, then becoming a part-time tutor, a full-time tutor and a course manager (his current role).

In the following section, the responses of the teacher and college lecturers are considered together (collectively referred to as ‘teachers’ for brevity), with significant differences of experience in the two sectors flagged.

The school-college partnership
The local technology-specialist school and the FE college appeared to have a particularly effective working partnership for teaching the Engineering Specialist Diploma. Tariq emphasised the consistent level of communication and co-operation between the two institutions, led by himself on behalf of the school, and Richard on behalf of the college. ‘What we do is liaise with the college so that we can reach mutual agreements. When that relationship is distant it can cause problems…If I send an email to Richard I know that he’ll send me a response within hours, which is fantastic. I’ve talked to other teachers at schools who are teaching the Diploma. They

have very little communication between them [and their partner colleges] and I think that creates barriers. Richard and me are working hard to fight these barriers, so we work together as a team.' The teachers worked together 'so that we have consistency' regarding assessment and coverage of content. Tariq saw this level of effective team-working as an intrinsic element of engineering professionalism. 'That's not just within a school. It's in industry in general. Being part of a team you have to get along, you have to get things off the ground and you have to do whatever it takes.'

For the college's part, it had benefited from dedicated funding of £1 million for its Specialist Diploma teaching room. The college lecturers had insisted on being closely involved in the specification of the teaching space. For example they insisted on work stations where the computer monitors folded away so students had clear surfaces for drawing and writing by hand, something they feel is an indispensable part of proper engineering education.

The Specialist Diploma in Engineering
Tariq was involved in the consortium that designed the pilot of the Engineering Specialist Diploma. 'A lot of input was put in from the Royal Academy of Engineers, and from LEP [London Engineering Partnership] as well….I think last year we had 15 meetings, whole day activities…and that includes organisations, the examination board came together, the website came together, the 14-19 came together. It's been a lot of work from everybody.' He was positive about the Specialist Diploma, feeling that, as 'engineering is such a wide field', a 'standard GCSE' could not match the coverage it offers.

Characteristics of talented learners
The teachers were asked about the characteristics and attributes of talented learners in engineering, and were invited to relate this to Clow and Haight's KAMIS model of talent in vocational learners (2007), if relevant.

The KAMIS model of vocational giftedness

K: cognitive attributes: knowledge, skills
A: autonomy, leading to creativity
M: sensori-motor skills
I: intrinsic drive
S: socio-affective skills

The teachers all agreed that interest in engineering, what Richard called 'an added keenness', was a primary indicator. Ed linked intrinsic drive with autonomy, observing that some students enrol in the college early in the year, in January or February; 'I'm always amazed at how many 16-year-olds we see with no sign of mum or dad. They come down on their own…They are really self-motivated. …They're so keen that you think, "This young person really wants to do this".' In terms of the relative weights of the model's elements, there was consensus that, in Tariq's words, 'Intrinsic drive [is] more [important] than anything else.'

Richard noticed a link between confidence, autonomy and motivation. For vocational students, 'Most of the BTEC route is pass, merit, distinction, and if they're hitting those distinctions, the expectation is that for the next one, OK, they want another distinction. And we do see at the end of the year that they will get a distinction across all 6 units.'

With regard to cognitive attributes, the teachers cited problem-solving ability and mathematics as central to engineering talent. Richard said, ‘The maths in engineering comes out in every lesson.’ Phil was definite that for Access students to progress to university, ‘Maths is the top of the tree.’

When Tariq was asked about the characteristics that indicate a talented learner, he replied, ‘It’s very simple, that one: an eye for detail.’ Talented students not only understand how to achieve a particular brief, but can also predict possible problems and plan how to counteract or prevent them. ’They think about what needs to happen and they think about contingencies at the same time….Problem solving and forward thinking. The trouble shooting is very simple, but it’s taking that one stage forward…if you hand them a simple task, the amount of depth that they go into, including something that even a teacher wouldn’t think about.’

In terms of the sensori-motor aspects, particularly important in engineering as a discipline that integrates the practical and the theoretical, the teachers were divided about the prior experience students bring into the workshop, but agreed that talented students learned quickly. Speaking of his motorcycle mechanics students, Ed said, ‘Quite a few of them are very good with their hands…They’ve managed to fix things even, but they haven’t understood why…Then we start talking about the theory and “It’s much deeper and more involved than I thought.”’ In his electronics classes, however, Richard reported that, ‘you see students with lots of ability in maths and science and they can’t wire up a circuit.’ Tariq agreed, ‘You get kids who are very theoretically minded and they know absolutely everything, but they’re no good at making.’ Phil had also observed this among his Access students, ‘A lot of people haven’t got the basic hand skills [such as drilling or filing] …because they just don’t do so much of it at school.’ But when shown how (and why), ‘The ones with the high potential, they pick it up very quickly. They’re very particular and they’re working to tolerances, and … “If I don’t do it right, I’ll have another go”. They just push that little bit further.’

The interpersonal (socio-affective) skills the teachers identified included the ability to seek out and benefit from instruction. In the college context, among peers, it also included a learner’s ability successfully to negotiate the tensions between the behaviour needed to learn and the behavioural expectations of their peer groups. Phil said, ‘I’ve got a motorcycle student and I teach him electrics and he’s very confident of what he does. But often on the quiet he’s said, “I don’t want to be seen as I know, ‘cause I get a lot of stick, so I hold back”.’ This is not true for the somewhat older Access students: ‘They think, “I want to get to uni, and I’m going to get there. I don’t worry about what anybody thinks”.’ The teachers were unanimous on the importance of socio-affective skills in getting and retaining employment. Ed felt that ‘attendance, presentation, communication’ were of primary importance in students initially securing a job. Richard and Tariq also emphasised being able to work as part of a team, and Phil mentioned confidence, ‘in an interview it’s all about selling yourself,’ and thinking from the point of view of a potential employer: ‘If you know a little bit about the company, you’ve done a little bit of research, you can bring that up’ in an interview and ‘that could be a good thing.’

Recognising talent

The teachers were asked how long it takes to recognise high potential in a student. Most appeared to find this question amusing. Tariq, for example, laughed and said ‘About 2 or 3 minutes.’ Richard also laughed and said, ‘Day 1. Because the level of students we get from the schools, and the level of students in the borough, is so low, those with high ability stand out….You’d probably know just from them filling in forms.’ His more considered answer was that ‘it would take 1 or 2 pieces of work’ for ability to emerge. Ed would give the students somewhat longer, ‘say the first 6 weeks, the first half-term…before we could start making a proper value judgement.’ Phil felt that the teacher’s ability to recognise talent varied according to the personality of the students. ‘The extrovert ones you can probably spot quite quickly. The introvert ones probably take just a little bit longer.’ Both Richard and Ed, however, mentioned individual students who at first appeared unpromising (‘almost backward’, ‘a disaster!’) but who revealed considerable talent later on, when their motivation for learning had developed.

Nurturing talent in classroom and workshop
All of the teachers mentioned differentiating their teaching for their talented learners. Tariq felt that appropriate questions and tasks were of primary importance. Ed agreed, ‘Differentiation…If the whole group are working on some lower-level part of a motorbike,…we’ll give them the bigger motorbikes to do,…more tasks…a shorter time …we’ll ask them to report in more depth, or we ask them to help some of the lower achievers.’ Richard also mentioned ‘study buddies’, if the students agree, because the best way to learn something is to teach it. Phil concluded, ‘Keep them challenged. If they’re finding it easy and you’re not constantly pushing them, they get bored and could get disruptive…So keep them challenged and busy.’

All of the teachers mentioned the need for literacy and numeracy support. Richard said, ‘I try to get them to write as often as I can.’ Learning support is provided in both the school and the college, but all the teachers felt that additional maths support would benefit their students. Tariq felt that ‘with numeracy, it’s an internationally spoken language. You either have it or you don’t.’ His school did run numeracy weekends and special Saturday classes, but he felt it was better at supporting literacy and English as an Additional Language than remediating weaknesses in mathematics. Speaking about preparing access students for university, Phil said, ‘Maths is the top of the tree. Obviously English follows, but out of the two, maths is the key area.’ In the Access course, one-third of the teaching hours every week is spent on mathematics, to get students up to A-level standard in one year. ‘So its heavily Maths-biased, because that’s what the unis want.’ Richard would like to run additional maths classes for his electronics students ‘because there’s still huge gaps between when they leave here at level 3 and go to university. To bridge that gap a little bit would be a good thing.’

The articulation between the theoretical and the practical in engineering was an important aspect of teaching. Richard said, ‘For the students with high ability theory-wise, it’s helping them to apply it. We do try and have lots of practicals here.’ He also liked to get his students to draw by hand, rather than rely completely on software. Phil regretted the fact that ‘basic hand skills…[have] been slowly taken away from the schools. So when we ask the kids to do some simple exercises like drilling or filing, they haven’t got it…A lot of the Access people don’t have that either, so one of the first projects I do in the Mechanical course is [get them to] file some metal straight. …[Because] for the ones that go on to do aerospace, one of the first projects they do at Kingston University is they give [the students] a block of metal and say, “Make this part for a jet engine”. They give them no machines, it’s all hands.’ Richard concluded, ‘The relationship between theory and practice works both ways. . . Just like theory can help students understand the practical applications, practical work can also help students understand the theory,’ an observation borne out by the student interviews, for example with Antony and Paul.

In terms of motivating high ability students, Tariq observed, ‘They are hungry for hands-on, and the best way to motivate them is to throw them in the deep end. For this, he felt group work and scenario-based tasks was useful: ‘Give them a situation and see what they come up with… In industry you'll be doing a lot of team work and you'll be required to deliver, so I try and do that in the classroom.’ This is an example of applied learning and Authentic Pedagogy as discussed in Section 1 (Harkin 2007; Newman and Wehlage 1999)

There was clearly an ethos of encouragement in the teaching in the college, perhaps especially needed in an area of high social deprivation. Ed said, ‘I've always been amazed at how few of my students have mum and dad at home… Some at 16 may even be in a hostel. Not a nice place to be. There's no support for them there. They have money worries…peer bullying worries…gang worries…They're often so worried or so tired or so undernourished… that they can't give ten-tenths to the educational side.’ Nevertheless, ‘When they find out that if they drop something or mess something up, no one yells at them or tells them they're stupid…they say, ”Hey, I could learn here,” and relax….You need to praise them far more than you tell them off. And I think that has borne fruit.’ It certainly chimes with Mike's appreciation of ‘an encouraging word’ and an atmosphere where ‘they smile and say. “That's really nice, man”.’

Sources of support

Both the college and the school provided out-of-hours engineering clubs or open workshops for their students, as well as more generic support for literacy and numeracy, as well as library and learning support in the college.

The secondary students appeared to benefit significantly more from governmental initiatives and external bodies such as the London Engineering Project, which included ‘special residentials… weekends and trips, or one-day outings’ that might involve ‘a Royal Navy [event]…helicopter rides and boat rides,’ according to Tariq. He added, ‘There's a lot of planning that goes into these trips and a lot of money.’ This support also involved access to a number of inspirational speakers. Tariq felt that ‘the best thing they've done in the engineering consortium is that they've got a set of speakers. All you have to do is drop your name to them, give them a time and a day and they'll provide a speaker to come into school…There's no way we can talk about all these specialist areas, but the people who work in these areas love their job and so are the best person to talk about [it]. So these motivational speakers come into schools from all areas of engineering, and you can't beat that.’

A similar level of external largesse did not seem to be available to the FE college students. As the student interviews indicated, Mike would have liked more access to ‘motivational speakers’ and Antony would have liked visits ‘to places that involve engineering to get some insight into how it is’ and to meet practicing engineers in various fields. The college does provide extra-curricular events, both generic (eg an HE Fair, visiting writers, and the activities of the Student Performance Team) and engineering-related (eg the Wednesday engineering club, visits to the engineering departments of universities such as Brunel and London South Bank, and trips to the Motorbike Show at the Excel Centre in Docklands). But the college lecturers did not speak of the same embarrassment of riches that Tariq described.

None of the college students or lecturers mentioned the FE students having access to the LiveJournals e-mentoring website. The London Engineering Project website emphasises the importance of ‘the post-16 to higher education transition’, and mentions working in schools and colleges (LEP 2010). A request for further information revealed that the host college is one of the two London FE institutions the Project works with, but that there was only one event (an A-level Electronics Day, held at the other college) run in an FE institution in 2009. Its officer confirmed that the

Project offers FE colleges a number of activities, but these invitations are not always taken up (Hawthorne 2010).

The secondary school also appeared to have better access to employers. Tariq described the secondary students' '2 or 3 week work experience'. He tries to 'liaise with employers and tell them, '"Can you please put [the students] in different areas, so they get exposed to more, rather than just seeing one discipline." And the employers are aware of that.' This contrasts with the reports of Richard and Ed, who regretted that work experience is 'ever so difficult to organise, and expensive. So [for] courses, apart from vocational access courses [for 'youngsters with learning disabilities'], we're not able to do it.' Richard expressed considerable frustration about this, 'We have very little contact with employers, which is an absolute travesty. I think that would be the big thing that would really help….I would bend over backwards to gear [our courses] toward any company that took an interest, to ensure that the students were going down a route that the company wanted them to go down….It's the one thing that really pains me.'

Perhaps this reflects the difference between compulsory-phase, school-mediated 'work experience' and the type of placements that might be closer to real world-of-work experiences, which may well be more difficult and time-consuming to organise. Ed mentioned the difficulty of restoring relationships with employers who had had bad experiences of taking FE students on placements, even if they came from a different college. When asked about the constraints to organising more effective work experience, Richard pointed to a lack of time and human resources (eg the college's Advertising and Business Development unit has 1.5 staff). This reflects the FE sector's well-known problems with underfunding, but the contrast with the well-resourced pilot year of the Specialist Diploma is striking.

Advantages, constraints and key influencing factors

The teachers mentioned the importance of family and role models in influencing or supporting young people in pursuing engineering. Richard said, 'We see a lot of siblings coming through, so they've got that in their family and there's the drive there.' Having hobbies and outside interests in engineering-related areas also helps, according to Phi. Ed emphasised that 'the ones that are more successful are the ones that grew up doing things others didn't…making airfix model aeroplane and boat kits, the ones that grew up using their Oyster cards to look around London.' Ed was also emphatic that the ordinary skills of self-regulation such as punctuality were vitally important for his students to progress, particularly in employment.

On the negative side, peer pressure and bullying, including cyber bullying, were mentioned. Phil: 'With youngsters it's definitely peer pressure…They don't want to be seen as the geek of the class or whatever.' This diminishes as students get older, he noted.

Each of the teachers mentioned the 'gender split' as a key factor that might hold talented engineers back. Tariq observed, 'I think the biggest barrier that we have in engineering is gender. We have to overcome that.' He and Ed both emphasised the need for teachers to include the type of 'projects which will appeal to girls, to do more with the environment and community'. Parents also have a role to play in this, Tariq felt, in 'providing children with project-based toys where they have to make or build something.'

The FE students, being older, tended to be less cushioned against financial difficulties and the other responsibilities and vissicitudes of adult life. Richard said, 'From 18-19, they're heading off to work; they start to get jobs. And some of the overseas students…may be stacking shelves in Tescos or Sainsburys…[who] may not be very flexible with the hours….So I've lost 2 students to that this year.' Childcare can be a problem for some students, Richard noted, adding 'students with high ability more often than not will be female in engineering.' Ed, Phil and Richard all mentioned bullying and gangs. Richard told the story of 'one student in particular…so well-mannered, polite…a great character, he was out there driving the group. Got an excellent result in his GCSE in Engineering. Went on to the National Diploma and was doing fantastically well and was obviously going to do it. He got into a fight and stabbed somebody and now he's in Feltham Young Offenders Institute. And I think that can happen to quite a few students.'

Richard was unimpressed with the Connexions service. 'I'm very against the way Connexions works at the moment. You often see 14-, 15-, 16-year-olds outside the Connexions office with cans of beer. It's aimed at 'the wrong end of the market' so to speak. I think the old youth clubs were a better system.' His view that Connexions was failing ordinary young people who were not trouble-makers was echoed a few months later in the report of the Panel on Fair Access to the Professions, which noted 'The Connexions service seems to have focussed on the disadvantaged minority to the detriment of the aspirational majority.' (2009: 6).

The greatest frustration was reserved for the problems the FE students had with retaining benefits while they studied. Richard said, ' When students get over 19, they have to go on Job Seeker's Allowance. Some of the offices will accept 16 hours [of study] per week, and others will say 16 hours per week is full-time [study] and [the students will] either have to leave the course or they'll stop their Job Seeker's Allowance.' Phil saw a lot of this with the Access students. 'You get students who are signing on for Job Seeker's and the Job Centres want to put them on a course. The favourite one is a course about how to fill in cvs and application forms, which is about 2 months long. So they have to withdraw [from the engineering course because] they're told, "If you don't attend we have to take your benefit away."…So I lose people through the Job Centres and in terms of my Access students, that's the biggest loss. I'm always battling with Job Centres…And it does matter who you get at the Job Centre sometimes. I can get two people who sign on at exactly the same place, exactly the same benefit, they're with two different people, and they'll do two different things…If [the student's] got family they lose it all. They've got to give up, haven't they, and they end up in some silly little job somewhere when they're trying to better themselves.'

When asked what primary schools could do to spark interest in engineering among children, all the teachers mentioned 'fun': 'get them playing with very practical things' (Phil). They suggested clubs and special projects 'where they can actually make something…It has to be something that they look at and feel proud of' (Tariq). Again, this echoes the Authentic Pedagogy approach as well as Renzulli's Type III Enrichment model. For secondary schools, Richard emphasised the importance of establishing a solid foundation in 'the basic skills of reading, writing and arithmetic…It is far too common for us [in the college] to start off at the beginning of term finding that we need to teach basic GCSE skills before we are able to teach engineering subject material'. Richard praised secondary schools for 'allowing students to take their GCSEs a year early, in maths…But students who score an A or a B then have a wasted year…So [my advice] is to use that time' extending and consolidating these students' mathematical proficiency.

Progression routes and destinations
Students successful enough in their studies (and fortunate enough to negotiate the challenges and constraints in their personal situations) progressed into higher education or employment. The college makes considerable efforts to liaise with universities, and has good relationships with the engineering departments of several London universities. Both Tariq and the college tutors encourage talented students to aim for university places, as the interviews with both the secondary and the FE students demonstrate. In recent years, with the inclusion of vocational qualifications in the UCAS tariffs, Richard has seen the college's university-bound students disperse to a wider geographical spread of universities. 'It used to be that they went to London South Bank University, but now, for the BTEC National Diploma, with its UCAS points, they've branched out and they're going all over. Still a lot in London, but also Southampton, Brighton, Brunel, Kings, all over.' (Ed also mentioned Kingston University in London as a destination of choice.) The furthest HE destination was the University of Edinburgh.

Financing was an issue for these students. Richard said, 'They have to start getting loans….I don't know how keen I would be now to go to university if I thought I was going to end up with a £20,000 debt. Particularly in the current climate, where you're not sure you're going to get a job at the end of it. It's a big investment, not just of money but of time as well.' Phil felt that the awareness of 'all sorts of grants and bursaries…[is] slowly filtering down to the youngsters. "So even if I'm going to walk away with a student debt, it's something I can achieve." And as employers want the HE qualifications, it's the place to aim for, isn't it?'

In terms of employment, successful students in Ed's motorcycle courses sometimes got part-time jobs while still at college. 'And all of those without exception have then been transferred eventually into full time and those have all been permanent jobs. Some have been in jobs now for close on 6 years.' It must be added that not all students are lucky enough to work in engineering, and often, as Phil and Richard reported, due to employer inflexibility or the complications of the benefits system, 'end up in some silly little job somewhere'.

Part Two: The view from the university

The college and university have been working together on a joint engineering Access programme for over 20 years. Neither institution collaborates in this way with any other college or university. The FE Access students attend the university one day a week to study electronics or computer-aided engineering. They work on modules that become progressively more difficult through the programme, with the early modules spent (as one of the academics explained) 'just getting to know the machines' and later modules focused on 'certain topics like internal resistance, etc.'

The students interviewed in this study were talented college students on the Access course, ie following non-A level routes, who were working towards their goal of studying for an engineering degree. The HE lecturers both taught on the Access course. Students and lecturers were interviewed at the university in June 2009.

University students

Scott
Scott is in his early twenties and has a mixed White-British–Black Caribbean heritage. His father studied electronics in a technical college in Jamaica before emigrating to the UK. Both his parents work in a television factory in this country. Scott attended secondary school in a district of greater London, an experience he did not regard as particularly positive. He left school with an A grade GCSE in Religious Education, a D in Mathematics and Cs in his other subjects. After that he dropped out of mainstream education and joined the Army for just over a year, a formative experience during which he learned a lot about himself. He also gained a City & Guilds Key Skills qualification. Subsequently he attended college and took a BTEC First Diploma in electrical and electronic engineering before enrolling on the Access course. He has a conditional place at University College London to study electronics with nano-technology.

Kate
Kate is White British, twenty-six, and has worked as a sound technician for the past 5 years. Although she liked science in school and described herself as very good at physics, she truanted a good deal and left school with only 3 GCSEs, none of which were in mathematics or science. She went to college to do additional GCSEs, and progressed to the Access course. Currently she combines studying with caring for her aunt, which leaves her no time for a job. Kate has a conditional place to study engineering at the University of Edinburgh, on a five-year programme.

Luke
Luke is in his mid-twenties and previously studied electronic engineering at a technical college in his native Eritrea. When he came to London, he found that his qualifications are not recognised in the UK for university entry. He started the Access course in order to gain recognised qualifications, and finds the course content too easy. Luke has a conditional place to study electronic engineering at Queen Mary College, London. He has no family in Britain and does not know when, or whether, he will be able to return to Eritrea.

Attitudes to engineering
The students were all motivated by a strong intrinsic interest in engineering. Luke found his experience on the course quite frustrating, observing that nothing in the maths, physics or electronics aspects presented him with a challenge, something he clearly would have liked. Of the course content he had studied so far, Scott enjoyed the logic gates and circuit theory most because 'there seems to be a straight line of

thought going through it.' Kate said she found all aspects of the course quite easy. 'I like it all, that's why I found it easy. I do have to study of course, but when you study something you enjoy, although there are things that might be difficult at first, it is easy because of the rewards.' She had an appetite for content: 'I personally have been working through the A-level books because when we get to uni we're going to be working alongside people who've done A-level maths, A-level physics.'

Attitudes to learning

Mathematics

The areas of the curriculum that caused most difficulty for Scott and Kate were mathematics and the more theoretical aspects of engineering. Luke, with his prior learning, said he found the standards of the course rather low and, compared to his experience in Eritrea, felt that learners in the UK are not expected to work hard or to be assessed with any rigour.

When Scott (with his D in GCSE Maths) was asked whether there was anything he wished he'd been better prepared for when he arrived at university, he answered, 'Maths, definitely maths'. He explained, 'I may not see straight away the practical purpose of the maths I'm learning… I like a very tangible learning process. If I am given a piece of paper saying this is this because I say so, because I'm the teacher, it just doesn't fly. …It's the gap between the real and the imaginary; the theory on paper… Maths is worse [than chemistry and biology]. You think it's imaginary, especially when you get to complex numbers and you start to get imaginary terms and real terms and you think to yourself, if it's imaginary, why do I have to take it into account?...You just switch off.'

Kate admitted, 'The maths at first was horrendous, because I had no background with maths at all. I had so many problems at the beginning and they had assumed a certain amount of knowledge. I'd got on the course based on my work experience. So I had to work really hard at the beginning to get to that level.' She did this mainly through independent study: 'I took GCSE maths alongside [my Access course] and I just taught myself from books.' In her opinion, there are problems with the way that maths is taught in secondary schools, 'I don't know whether it's just a London thing or whether it's something in the state school system, [but maths is] just not considered important or… it's considered that it's something you're either good at or bad at. It's this attitude, "Oh well, *they're* good at maths and we'll spend time on *them*." Whereas actually maths is a very important thing for everybody, whether you are going to go into engineering or not, you are going to need it in life.'

Kate echoed Scott's point about 'a very tangible learning process'. 'Sometimes maths are a bit abstract, you need to be able to visualise and relate knowledge to other things…I like to *do* something. For example, if it's maths if someone can show me how to do it, but unless I've sat down and practised it a few times it won't sink in.' But she added firmly, 'Maths is something everybody can learn. It's not special, it's not magic, it's something that can be taught.'

Luke's comparative experience in Eritrea, perhaps not a country well known for its highly-developed educational system, is instructive. He felt that the standards of the Access course are rather low compared to his experience in the technical college in his home country, where he felt that maths, for example, is developed by engineering students to a very high standard. This is, perhaps, due to the fact that he had already covered the course content in his Eritrean college, but had to repeat it to earn a recognised qualification that gives him entry to a British university.

Problem-based learning and Authentic Pedagogy
Scott in particular enjoyed learning in situations that mirror real-life contexts. He would have liked his course to include ‘more team building…Give us more of a free hand. Give us a problem, [so we have to] do the research…just like [in] any company.’ He also liked collaborative learning, and would have liked the teachers ‘not [to] say to us “You do it on your own,”’ but instead to allow students to ‘refer to others’. Luke also had a thirst for authentic, real-life situations. He wanted help with practical experience in an electronics company, something not available to him in Eritrea, but also, so far, not in London either. He was disappointed that neither the university nor the college had been able to find him a placement.

KAMIS model aspects
The students each exhibited a level of knowledge and skills (the K in KAMIS) that brought them to the attention of their lecturers, who nominated them for interview.

No specific information was available on their sensori-motor skills (M), although Luke’s previous qualifications and Kate’s employment history attest to an acceptable level of competence in this area. Kate noted, ‘I’ve really benefited from the theory, but it is quite good to do practical work… be given a circuit and have to figure it out yourself.’ Scott felt there was ‘not enough “hands on” time with equipment and components’ in the course. ‘I wish there would be more integrated circuits, fabrication of materials.’ He would prefer it ‘if we managed to crack open a computer once in a while to see how the electronic components are stored and why and what principles you should take into account’ (a nice articulation of the interconnection between the practical and the theoretical in engineering).

Socio-affective skills (S) are implicit in the good relationships with their teachers and fellow students that each of the students mentioned. Scott was the most reflective and forthcoming about this aspect of being an effective engineer: ‘Communication skills, without a doubt…When you get into the world, you need to interact with people, and tell them, without insulting them, that they’re wrong and you’re right. If you don’t have the proper skills than you come across as arrogant, even when you are not.’ Initially he found he was not prepared for ‘the [college and university] teachers being so tough on you, because of secondary school being so soft.’ But he had clearly come to terms with this and valued the benefits of his personal relationships with his lecturers. ‘You still can get on with them….You get a sense of being equal and it makes it far easier to ask questions.’ He said he would counsel other young people who wanted to go to university, ‘Don’t get cocky, don’t be arrogant. Don’t be afraid to take time out during the weekend rather than going out….Take time out for yourself to chill out.’

The facets of the KAMIS model which were the most strikingly evident in the Access students, however, were intrinsic drive (I) and autonomy (A). Luke had taken the immigrant’s path, leaving family and friends behind, negotiating life in a foreign country and language, navigating through a complex educational system that discounted his previous achievements, in order to steer a course toward his goal of a place in a prestigious, research-intensive university. Kate also demonstrated high levels of independence, motivation and focus. When she was asked about group work, she answered, ‘Sometimes with groups you can find that the strongest personalities take over and everyone else sits back and let their weaknesses get bigger and bigger. If you’re on your own, you’re having to deal with them. I’ve just used the course as a guide to take away what I need to learn to get up to university level, so I just go home and read about it.’

Scott had surmounted considerable feelings of alienation about his secondary education in order to take advantage of subsequent chances to learn. He showed independence of mind from an early age, ‘Instead of watching kids’ daytime TV when I was growing up, I was watching the Discovery channel.’ He also appeared to demonstrate a level of autonomy that, combined with a certain type of intelligence, manifests itself as creativity. When asked about his long-term plans, Scott answered, ‘Research and development and maybe my own lab…The other half [of engineering] is imagination….I have imagination pouring out of my lug holes. I want to be able to let rip with my imagination with reference to my knowledge.’

To some extent, these interview findings replicate Manstetten’s conclusions that talented German vocational learners were particularly characterised, not so much by high levels of intelligence or creativity, but by high motivation (Manstetten 2000: 444-5). However, Scott’s self-reported creativity is at variance with this.

Sources of support

Her high level of intrinsic drive, independence and motivation was perhaps a fortunate dimension of Kate’s temperament, as she felt she had virtually no support from her family for her aspirations. ‘Regarding my family, I don’t really get any support. For me, it’s because I’m female, my family don’t really understand why I would want to do anything other than history or art.’ [Has this lack of support hampered you?] ‘Yeah, totally, totally. …I would have done this years ago if I’d have got the right support.’ She turns to her teachers when she needs to understand something on the course. And ‘I have a friend doing A level maths and I phone him sometimes if I’ve got a problem.’ Luke, who has no family or longstanding contacts in the UK, found his tutors, especially the college tutors, very helpful, and also had supportive relationships with his fellow students.

Scott indicated that he received a high level of family support, especially from his father, who had himself been educated in electronics. ‘If I needed help [for example with the BETC course] I could ask him.’ When asked about what family and friends could do to support engineering students, Scott said, ‘Be there more often…Instead of going out with their friends, to come and sit down and say, “How was your day? Anything wrong?” and actually mean it…I’ve had that, especially from my dad.’ A number of commentators, including Tony Sewell, have written about the crucial importance of engaged black fathers in the social, emotional and intellectual development of black boys (Sewell 2009: chapter 2 and passim). Scott’s resilience (as well as Antony’s aspirations to ‘maybe go and get a Masters…and then maybe later on, go for a PhD’) is an example of how positive this influence can be.

Advice for earlier phases of education

In their secondary education, both of the two British students had prepared for traditional GCSEs and A level qualifications, rather than for the newly created Specialist Diploma. Scott indicated that he would have liked something equivalent to the Specialist Diploma when he was in school. ‘Instead of GCSEs, they should put the BTEC into school so that you have the practical. So even if you have theory, you’d have a practical to re-affirm some of it.’ He also expressed the value he placed on teachers showing passion about their subject, and recommended that it would be helpful for young learners interested in engineering if schools ‘have companies involved a little bit more…show us where all this maths, all this theory, is coming together.’

Kate was definite that ‘maths, at least to GCSE, is something that everybody should have’. She said, ‘I was shocked when a friend with a nine-year-old son was told, “He’s no good at maths.” What do you mean? He’s nine years old!’ Her advice to schools was ‘Don’t tell [children] what they’re good at, teach them the core subjects and when they’re old enough they can make an informed choice, but they can’t make any kind of choice if they’re not given the right tools.’ In her own case, ‘I didn’t even know what engineering was when I was in secondary school. I don’t think I was aware my interests were in engineering as such, just that I liked to fix things and look for solutions.’

In terms of advice for the further education sector, Kate observed that ‘I feel the college, pressured by the targets placed on them, can’t spend as much time teaching the students because they are worrying too much about getting the students to pass….If there’s a student who doesn’t want to learn, they’re so worried about getting that student to pass that they are taking time away from all the students who are trying to learn.’

Plans and aspirations
In the future, Scott thought he might go into research and development. Kate, somewhat older and already with 5 years’ experience of employment, wasn’t sure what she would do after university. ‘I’ve got an open mind…I’ve got to decide where my strengths lie and what I enjoy. If they meet in the right place, that’s where I’m going to go.’ Luke’s position, as an overseas student, did not allow him to formulate clear plans for the future. He was not sure when, or if, he would be able to return to Eritrea.

University lecturers

David
David started his own higher education in engineering as a Higher National Diploma (HND) student before transferring to the degree programme. He worked in industry for a while, ‘decided I didn’t like arguing over who pays for everything’, and returned to study for a doctorate. During this time he started lecturing, and currently teaches on most of the engineering undergraduate courses. David is the course director for the HNC (Higher National Certificate) and HND. He had worked with the college on the Access course for over 18 years, over which time there had been some key changes in emphasis. He described the partnership with the college as ‘a good working relationship,’ with university staff attending the college’s exam boards and good communications between engineering lecturers in the two institutions. FE staff and (non-Access) students visit the university from time to time, and many of the college’s Access students progress to degree programmes at the university.

Jean
Jean’s background is in physics, in which she holds an undergraduate degree and a doctorate. Her area of interest is wireless technologies and she teaches the FE Access students electronics for their projects. Jean had taken over responsibility for her department’s collaboration in the college’s Access programme two years ago. At the time of interview, she had plans to make some changes to the programme’s curriculum, focusing on fewer, larger projects underpinned by ‘more time on the fundamentals of concepts of electronics.’

Transition issues
As the London Engineering Project’s website emphasises, ‘the post-16 to higher education transition’ is crucially important for the development of the next generation of professional engineers (LEP 2010). It is instructive that both of the university lecturers emphasised structural issues in the organisation, scheduling and educational aspects of the Access course, that posed difficulties for the learners. David had been with the course almost from the beginning, and felt that recent

changes that accelerated the educational pace and escalated its level had been detrimental. The university's Access course was originally 'designed to feed an HND course after one year of study. This worked very well for years. About 90% would pass …and go on to the HND.' (Richard, the FE lecturer, for example, had taken a similar route, and gone on to earn an engineering degree.) David regretted that recently the course had been 'hijacked'. 'It's been decided that Access courses are now a prerequisite to feed a degree. I do not think in one year you can take students who know very little and prepare them for an intense BEng course. There are some institutions who've been forced into widening access, who are taking these Access students, and after one year they're saying "Sorry!" These students have actively been encouraged to apply for and take degrees, and I know from experience that they're not ready….I'm unhappy about students, after one year, being given false hope.' This undermined students' morale. 'For a while we had a remedial thing where people went off to do a degree, failed, and came back on an HND. That's not satisfactory because their confidence has been knocked.'

Even though it would take a year longer, David felt that a better option for many learners would be to progress from the Access course to the two-year HND course, because 'an HND course … is nowhere near as technical, and the teaching is completely different.' This route would give students increased flexibility: 'After two years they have the option of taking their HND and going into industry. That's a good qualification to have…So they can get an internationally recognised qualification after two years.' Students whose circumstances and ability permitted could 'take another two years to get a BEng' if they chose to, and 'come out with two qualifications.'

Jean reported that, among the Access students who worked on projects in her classes, 'only about 10% reach a [level] 3' (the expected level). 'They struggle to focus on what the question is….I don't think it's good for them to go into a first-year engineering degree with only their Access qualifications because I don't think it's good enough and they'll be lost.'

Both academics felt that the Access students' proficiency in mathematics was often inadequate for the demands of the course. Jean commented that '[the students have] shown me some sheets they've done [at college] and there seemed to be a lot missing.' David said, 'The people who come through the Access route are often better prepared for the practical side because they've done more before than the A-level courses. But for the theoretical part they're often at a disadvantage compared to the A level….A year at an FE college doing 3 days a week is not going to prepare them mathematically as much as a two-year, full-time A level course.'

Jean felt that part of the problem was grade inflation. 'I don't know whether teachers are marking exams more lightly but students are coming with less ability and with higher marks.' She was also less positive than David about communications with the college, feeling that there were gaps in the students' 'basic engineering and electronics knowledge' and that attempts to liaise with the college did not always result in requested information being supplied.

Characteristics of talented learners
The indicators of talent enumerated by the academics included 'clear, logical thought', which David nominated along with 'mathematical ability'. He commented that 'You're going to get able students from all backgrounds. Some are at different stages of development….The people who've gone through the A levels are normally better prepared in logical thought because they've done more of it for a longer time….With the Access students, they [often] need to start with really basic stuff.' He observed that, 'More often than not, the high ability students are those who've had

education somewhere else at some other point. Maybe a baccalaureate abroad or passed GCSE maths and then dropped out for whatever reason.'

Jean felt that talented learners showed an ability to 'focus very well', used 'a more managed and focused way of working,' and 'follow rules and codes'. She observed that 'Sometimes [Access students are] better than what I would expect from an A level because they're interested in the topic and want to learn. They also tend to ask more questions.' She also found that, because talented learners take the time to inspect and assemble equipment, and clarify the task and the expected outcome, 'they will always take about 20 minutes [longer] to start the experiment [than] everybody else.' The ability to ask informed, intelligent questions and seek advice about the quality of books on particular subjects were also indicators.

In terms of elements of the KAMIS model, Jean confirmed (unsurprisingly) that talented learners' cognitive skills 'appear to be stronger,' and that they are more autonomous ('don't need much prompting' and 'work very well independently'). On the other hand, 'if they get stuck they'll come and talk to me'. David also saw this as an indicator of ability: 'They need to be able to think on their own. But on the other hand, if you talk to someone else you can see how to look at something another way.' Sensori-motor skills were less important. David said, 'It depends what type of engineering you're going in to. If you're going to be a technician engineer then you would need motor skills. If you're going to be a chartered engineer than probably not so much.' (In the FE college, Ed credited a 'hatred of oil' as the reason one former college student had decided to do an engineering research and development course at university.)

Jean also echoed the FE lecturers in citing 'an interest in engineering' as a key characteristic of talent in the subject. She noted that the Access students tend to be 'more worried about what job they'll do [at the end of the course] than a normal A-level degree student, and are probably more specific, for example, wanting to work with railway lines or as a sound technician. They tend to have a vision of where they'd like to be.'

In an interesting echo of the comments of the secondary and FE teachers, David volunteered the information that 'We know within 2 to 3 weeks who's going to be good and who's going to be poor. How, I don't know. Maybe it's just experience. It's the way [the students] react to you, the way they answer questions, and the questions they themselves ask.' He reiterated Jean's point that talented students approach problems in a more systematic, process-focused way. 'Some students start things without thinking it through, while others will think about the process first. That's an indication of logical thinking.'

Nurturing talent in classroom and lab

When asked about the best way to develop students' talent in engineering, David replied, 'I think what we do is quite effective.' He described the university's teaching approach as lecturing, getting students 'to think rather than filling them with information', and 'developing their ability to apply knowledge to solve problems.' Jean was also enthusiastic about problem-solving: 'I definitely believe problem-based learning is the way forward.' This involved putting students into groups to solve problems as a team, with less help from teachers and 'a little bit more pressure all the time. More challenge and more abstract thinking, just to get them to a point where they have to work it out for themselves.'

In terms of motivating Access students, Jean said, 'One of the things that I've noticed is there's no point giving them long-term goals. They have too many outside worries.

So I like to give them short-term goals. Every week they have to have this done and that done.' This was helpful in keeping students focussed. (Ed had also mentioned this as a key teaching principle for his FE students.) Alan emphasised the importance of frequent, regular feedback. 'We have feedback in six week chunks. We interview every student, regardless of how well they've done, after the phase tests and after the end of the unit, and this is a sort of carrot–stick interview. Some people, you're shaking their hand and saying "Well done". [With] the other ones, it's more, "You've failed this, can you sort it out?"' David was convinced that 'The more the staff can get to know the students, the better things are. This is not specific to higher ability. Students are aware that you know how they're doing and we use that expression "on their backs" sometimes. That tends to motivate them and help them…that the students are aware that they're known.' This may be especially important for Access students, who are used to good personal relationships with their college lecturers.

For the more able students Jean said, 'In an ideal world I would add on extra work…something more academically challenging.' She felt this was not really possible under present arrangements with the college 'because I'm asked to give certain levels on the Access [course] so there's no point going higher, and I don't know what their timetable is.' In any case the very good students already asked her questions that took their learning forward. She added that, 'I'd like to do more hands-on things.'

Jean thought it would be an improvement if the Access course content were streamlined and rationalised, and suggested that it would be helpful to 'go through the units…and break them down into what's necessary if you never go to university. And then if [students] want to go further…the foundation is there. Then better students [could] have extra blocks and get extra merits for that. I think we could make it a lot more simple.' She felt that 'If the foundation year had less units and more fundamental applications such as maths, basic physics and so on, it would be much more worthwhile. You need to be confident in those basic principles.' David agreed that students need as good a grounding as possible in the basics before embarking on an engineering degree. 'The better the mathematical ability, the better the logical thinking, the better they do on an engineering course.'

In terms of timetabling, Jean felt that 'students should be taught over 3 or 4 days, not 2 very long days. That's exhausting, but it's the way the university works because most of the students are working and over a certain age, so it's decided that that suits them. How can it suit them when they fail?'

Sources of support

When asked about non-academic types of support for talented students from disadvantaged backgrounds, Jean replied, 'First of all, this category that they're in needs to be forgotten. That needs not to be discussed, that they came from an Access course.' Instead the university's attitude should be: You are here. You deserve to be here. We'll give you all the support we can.' She suggested this support might take the form of extra classes and 'someone hired by the university that helps those specific students,' for example, a 'lecturer from the FE college they came from, so they have that gap bridged and they're not left alone.' She added that 'if they were given financial help that would be great.'

Jean felt that having more industrial contacts and placements would be helpful for the students. Because arranging these is so time-consuming, however, 'it would be good to have a liaison officer' appointed by the university, someone 'qualified in the area [who] could build up a rapport and contacts in industry. It's a different social network to academic staff.' David, in contrast, felt that the university's links to employers worked quite effectively, possibly because of his greater involvement with the HND and HNC programmes. In these programmes, ‘the employers quite often come in and we talk to them’ and students establish informal networks to help each other with employment opportunities.

Advantages, constraints and key influencing factors
Both academics recognised the difficulties their students had with financial constraints and with combining degree work with a job. As David put it, ‘It would be better if they didn’t work but realistically they need to live.’ He said the university advises students to ‘spend as much time outside university on their [academic] work as they do inside’ and try to fit working around that. ‘It becomes a problem if they start doing things like night work, because they’re half asleep.’

David noted that ‘home and personal problems’ were the main constraints on students performing effectively and fulfilling their potential. But ‘if someone breaks up with his girlfriend or has to leave home, the university can’t really get involved with that.’ Jean reported that sometimes her students have problems ‘because they’re working …and things have happened at work, or they’ve got parents who are overseas and had to go to see them.’ Missing sessions can be ‘a huge problem’ for students, ‘what I really see is their lack of electronic knowledge when they come back, which means they mustn’t be getting it at college either.’

David observed that his students form support networks among themselves, and that ‘We actively encourage it’ as these social networks are a key factor in student success in the course. Jean felt it was more difficult and took longer for the Access students to build up friendships in the university because they were only on campus one or two days a week. ‘A lot of our students are over a certain age and they have part time work and it’s expensive to travel to the centre of London…Some of them are even supporting a family.’

Constraints in their personal lives, Jean felt, limited students’ aspirations: ‘I think sometimes [their aspirations are] below what they could achieve. I think if they were left without the financial problems some of them could be PhDs.’

Progression routes and destinations
Jean reported that after completing their degrees, the university’s engineering students took a variety of routes into employment, with some starting their own businesses and others going into ‘network engineering, internet security, high engineering jobs in London Underground, etc.’ Some of the overseas students ‘go back home and they tend to get good jobs there.’ Students from the university were among the most highly paid graduates from London universities: ‘I think that’s because we offer certain engineering topics that aren’t taught anywhere else, such as building services and things like that.’

David’s students on the HND specialised into a variety of types of engineering, and ‘the able ones will go on to the degree.’ When David was asked whether there was a correlation between ability and types of engineering, David replied, ‘I’m not aware of any correlation, but that doesn’t mean to say that there isn’t any. The more able tend to become chartered engineers quite quickly, so they tend to be working further away from the tools, shall we say.’

He felt the key attributes that made students attractive to employers were their ability to ‘fit in and relate to others’ as well as having a good technical and academic background. In his experience, the detailed transcript that HND students left with was attractive to employers as it gave them ‘an idea of how well the student performs overall, and which areas are their strengths and weaknesses. With a degree you just get a classification.' Jean felt that students' projects were of key interest to employers: 'that's what defines them as a student'. Also important are the ability to work independently, to be honest about their work 'and [about] how they've got their answers, especially what they do when they hit an obstacle.'

Both HE lecturers mentioned self-presentation issues such as interview skills and appropriate attire as being important to a student's employability, as well as the ability to produce reports in correct English.

Summary

Semi-structured case-study interviews with learners were carried out with ten students:

- 4 secondary students studying on the Engineering Specialist Diploma
- 3 FE students undertaking Level 3 vocational engineering courses
- 3 university students doing university Access degrees in engineering.

Teachers' perspectives were ascertained through interviews with six teachers:

- 1 secondary teacher on the Engineering Specialist Diploma
- 3 FE engineering lecturers
- 2 university lecturers teaching on the Access course in engineering.

In order to structure discussions about what talent looks like in engineering students, Clow and Haight's KAMIS model of vocational talent (2007) was presented for critique to the secondary teacher and further education lecturers, and used to inform the interview questions with learners. The model posits five key areas of capability that combine in vocational talent:

- **K**nowledge and skills
- **A**utonomy
- sensori-**M**otor abilities
- **I**ntrinsic drive
- **S**ocio-affective skills.

Responses from both teachers and learners indicate that the key facet of this model is intrinsic drive, often expressed as 'an added keenness' and passion for the subject. These characteristics were evidenced in the learners, and confirmed by teachers, with levels of motivation, independence and resilience increasing through the age groups and educational levels.

Both learners and teachers confirmed the survey findings regarding the centrality of learning through the practical, hands-on aspects of engineering and the difficulties with mathematics and theory. Teaching that maximised the synergies between practice and theory appeared to be highly developed and greatly valued by learners in the Specialist Diploma and vocational courses in the FE college.

Both teachers and learners in all phases found problem-based, collaborative learning to be the most effective way for students to master and apply challenging concepts, and reported wanting to use more of this. The FE and HE teachers regretted the absence of strong links with employers in the sector. The FE teachers described with feeling the difficulties in organising work placements for their students.

Most, but not all, of the students interviewed had high levels of family support. A few did not. The Access students without such support showed considerable levels of independence and determination in pursuing their studies, and found help from their teachers and fellow students. A number of the students had family or friends in engineering. The students reiterated the high level of appreciation for teachers shown in the survey. As one secondary student said, ‘The teachers teach you in ways that you understand.’ Supportive personal relationships with teachers were also valued, especially among the FE vocational learners: ‘They give you an encouraging word…If you [show them] your work they smile and say, “That’s really nice, man.”’

The teachers reported that constraining factors on students’ success included financial difficulties, family issues, peer pressure, bullying, and ‘gang worries’. Inflexible employers, shortages of child-care, and inconsistencies in the application of Benefits rules (such as those for Job Seeker’s Allowance) militate against retaining some talented learners.

The Specialist Diploma in Engineering appeared to be popular and working effectively in the partnership investigated in this study. The secondary and FE teachers had forged good communications and a good working relationship. (This was felt by the secondary teacher to be atypical among similar partnerships.) The collaboration between the college and secondary school allowed talented secondary students to be promoted into Level 2 vocational classes, an interesting development in terms of breaking down the ‘academic–vocational divide’. The college benefited from a £1 million refurbishment of teaching premises. However, there appeared to be issues of equity between the secondary school and the FE college in the distribution of other supporting facilities such as an e-mentoring scheme and enrichment events, with the college able to access fewer of these.

The university Access course was more problematical. Both students and lecturers would have liked more ‘hands on,’ problem-based and collaborative learning opportunities. The university lecturers felt that it was too hurried and crammed with content at the expense of laying a solid foundation of basic principles including mathematics. They felt that the promise of adequate preparation for ‘an intense BEng course’ in one year gave Access students ‘false hopes.’ From their end, the FE lecturers would have liked to increase the amount of mathematics on the course. They also reported that students arrive at the college ill-prepared to begin post-16 work at the appropriate level, with weaknesses in numeracy and literacy needing to be remediated before students can access core engineering content.

Section 4: Conclusions and recommendations

'If your hands are not involved in your scientific work, as well as your brain, it's not as good. I was lucky enough to have strong hands-on experience.'

James Lovelock
creator of the Gaia Principle and Nobel Laureate

The future of engineering?

An American automotive executive admitted in a 2008 study that it is now more attractive for his company to employ engineers from developing countries with high skill bases. 'The advantage from our perspective is that you are paying those guys anywhere from sort of $12-15,000 a year versus say a European or a US engineer at anywhere from $75,000 to $95,000 a year, with a whole bunch of benefits as well' (Brown et al 2008:7). The study involved research with 125 transnational companies and policy-makers in 7 countries (USA, UK, Germany, India, China, Singapore, Korea). The companies represented four sectors: automotive, electronics, financial services and telecoms (three out of four employing engineers). The study found that there is a growing and rapid trend for such companies to employ highly skilled workers from non-OECD countries, and specific policy among developing countries such as India and China to educate their populations for highly-skilled 'brain work'. The researchers challenge UK policy-makers' assumption that there is a straightforward linear connection between higher education and social mobility, given the globalisation of the knowledge economy.

The research found that 'Asia is already producing twice as many engineers as America and Europe together' (p 6). An interviewee from a Germany transnational company, 'expressed deep concerns about the supply of engineers and scientists from Britain and the United States' but admitted that this was not problematical for his company, because it employed Chinese and Russian engineering graduates instead. He believed that 'it would take Britain and the United States a long time to catch up with the quality of engineers and scientists being trained in Asia and the Russian Federation' (p. 15).

While this picture may appear bleak, it is worth remembering that a year later, on visits to China and Japan, members of the House of Commons Select Committee on Innovations, Universities, Science and Skills 'were struck by the respect held for British engineers and UK engineering' (2009) 104). A balanced view must be taken of issues regarding entrance to higher education and the professional levels of engineering. On the one hand, there is evidence that 'qualifications' inflation' means that a university degree is a 'hard skills' filter that represents the first hurdle in being considered for a good job (at least with transnational companies). A degree is likely to be necessary for higher level positions and entry to the professional levels of engineering. On the other there is convincing evidence from the same study that a degree is no longer a guarantee of a job (at least in transnational companies), given global competition for highly skilled jobs from lower wage economies such as China and India.

Not every company is a transnational, however, and the proportion of the UK economy contributed by such companies is lower that that contributed by locally-based small and medium enterprises. Local jobs and businesses, and indeed self-employment, may be more viable options for a number, even the majority, of young people, especially if Britain becomes the high-skilled, low-waged economy predicted.

Given this complex picture, it is worth bearing in mind that for engineering the stakes are high. Attracting, and effectively educating, tomorrow's engineers is an important endeavour. This is true not only because of issues of global competitiveness, but also for reasons of social justice for the many young people attracted to engineering occupations, whose talents and life chances must not be wasted.

Engineering as a vehicle for social mobility

The conditions necessary for true social and professional mobility depend on a highly complex set of factors, a number of them outside the control of national governments. There is a need for access and support for entry into a range of educational and training opportunities, and especially for a real commitment to lifelong learning.

The status of engineering as a 'broad church' encompassing a wide variety of occupations from craft to professional level, was described as 'regrettable' by the House of Commons Select Committee's 2009 investigation into engineering, who noted that 'there is nothing to stop anyone from describing themselves as an "engineer"' (pp. 107-8). Yet this very elasticity allows the type of social mobility and progression that can take young people such as Kate or Scott from truancy and disaffection in secondary school, through employment and study in a further education institution, to a place on a degree course in a prestigious university. Despite the jokes about bin men being described as 'sanitary engineers', this type of flexibility should not be lost.

Many of the learners who participated in the study, located in one of the most deprived boroughs of the UK, demonstrated a real appetite for the intrinsic fascination for the realm of engineering, what Renzulli has called 'the romance of the subject.' Their interest was nurtured by teachers who struggled against difficult circumstances to foster their abilities.

This fascination for the subject was defined by the teachers as one of the key characteristics marking out students of talent. Some of the learners in the college demonstrated an aptitude for the subject noticeable to their teachers as early as 'the first 2 or 3 minutes.' Of course teachers at secondary and further education level should cater for the learning of all young people, whatever their apparent level of potential. Despite the age-normed National Curriculum 'levels', individual developmental trajectories are not the same for everyone and do not proceed at a smooth, regular pace. Individuals develop and learn at different speeds throughout their lives, a fact confirming the overwhelming need for, and value of, second and multiple chances to learn, such as those offered by further education.

Current, evidence-based models of 'high ability' however, stress motivation and 'mindset' as well as cognitive abilities, as key drivers. Sustained practice (the 10,000 hours model) has been shown in a number of disparate domains to be the primary factor in turning potential into 'expert performance' (in mathematics as well as tennis, for example). These reasons justify the need to recognize and nurture young people whose 'added keenness', 'clear, logical thought' , 'mathematical ability', 'eye for detail' and disposition to 'look for solutions' and 'push just little bit further' all mark them out as talented in engineering. This is particularly true if the ambitions of progressive organizations such as the Stephen Lawrence Charitable Trust and the London Engineering Project to increase the numbers of under-represented groups such as minority ethnic and women students in urban design, engineering, and related domains are to be realized.

The educational phases and routes considered in this study, from the secondary-level Specialist Diploma through further education vocational courses to the university Access course offer a coherent, if not perfect, pathway to degree level study in engineering and beyond, for those students, often from 'non-traditional' backgrounds, who are able, motivated and fortunate enough to follow it.

Work-based Foundation Degrees, not considered in this study, offers another branch of this route, allowing students already in employment to continue earning a living. Some candidates with jobs have their studies supported by their employers, and find themselves in the fortunate position of earning a degree without incurring debt. While this option is not available to everyone, foundation degrees, especially in partnership with employers, integrate theoretical and applied knowledge, and offer a valuable pathway into higher-level career opportunities, as well as a bridge across the false vocational-academic divide (Ross 2009).

Characteristics of learners

The survey participants and interviewed students at secondary, FE and HE levels all showed a marked preference for practical, applied learning. This showed itself as a hunger for authentic, problem-solving learning activities; in Tariq's words, 'hungry for hands-on'. In the main, this included an element of collaborative work.

The students showed a high level of intrinsic interest in engineering. Among the interviewed students from FE and especially from the Access course, high levels of autonomy, self-motivation and personal resilience were strongly in evidence. Most of the students referred to their own responsibility as learners to apply themselves and put in the effort to understand difficult content.

Personal interest and motivation were also key elements cited as indicators of engineering talent by the teachers at all levels, along with cognitive abilities in mathematics, logical thinking and problem-solving. The teachers also emphasised the importance of the practical, hands-on aspects of engineering, and, for employment success in the sector, of good communication and team-working, and appropriate personal presentation.

All of the students highly valued the helpfulness of their teachers. The personal relationships with their teachers and the ethos of encouragement in the college were particularly important to the secondary and FE students. In the college, the engineering professionalism and self-identification of the teachers was a positive influence. Tariq, Richard, Phil and Ed had all worked as engineers and co-operated to create a 'community of practice' where the role and identity of 'engineer' were modelled for the students. This clearly had an impact, with Carlos suggesting that secondary schools could help engineering students by having more expert teachers. Sternberg's description of 'talent' as 'developing expertise' is salient here, as is Vygotsky's notion of the 'zone of proximal development' (the learner's opportunity to develop when working with someone of greater knowledge or experience). The fact that a number of the talented students had family or friends with experience in engineering is notable, but it is also true that not all the student interviewees did. In both the online survey and the interviews, teachers were regarded as crucially important in helping students understand content. As Tommy said, 'The teachers teach you in a way that you understand.' The interviews in the college highlighted the importance of both teachers' professional experience and their personal attributes: 'They give you an encouraging word…They smile and say, "That's really nice, man."'

The Specialist Diploma in Engineering

It is early days to judge the effectiveness of the Specialist Diploma in engineering, but, at least in successful partnerships such as that between the school and the college in this study, the outlook is positive. Teaching appears to be well designed to meet the requirements of the subject and the needs of the learners. The communication and co-ordination between the secondary and FE teachers is good, and their commitment to the subject and their learners is evident. The partnership had received considerable funding and expert input from government and bodies such as the London Engineering Partnership.

The secondary students on the Specialist Diploma enjoyed the more grown-up atmosphere of college. The college had established synergies between the Specialist Diploma and vocational courses, promoting the brighter Diploma students to the Level 2 NVQ class, and employing talented Level 3 vocational students as Learning Support Assistants for the secondary students. This suggests the potential of the Specialist Diplomas to break down of the traditional compartmentalisation of 'academic' and 'vocational' education.

Anecdotal evidence, the observations of the secondary teacher interviewed, and the findings of the 2009 National Grid report all indicate that the Specialist Diploma in Engineering does not work so well in many other partnerships. A lack of teachers with specialist subject knowledge and relevant vocational experience is a key issue for Engineering Specialist Diploma. The issue of lack of capacity to deliver policy objectives in vocational learning was raised by the SKOPE report in 2004 (Stasz et al 2004: 63). This was reiterated with specific regard to the Specialist Diploma in Engineering in the National Grid report, which found that some FE teachers participating in their study raised issues around 'a shortage of qualified teachers who are able to teach an Engineering Diploma, feeling currently there is an over-reliance on DT (Design and Technology) teachers to teach engineering courses' (National Grid 2009: 24).

These issues are of national concern, and to some may raise doubts about the viability of the Specialist Diploma. However, this makes it even more important that flagship partnerships such as the one in this study are allowed to bed in and flourish, so that important lessons about how the programme can be successful are learned.

The importance of further education

The further education sector tends to serve as a collecting and remediating point for disadvantaged young people and those disaffected with earlier experiences of education. A number of recent reports attest to the key importance of further education in providing education and enhanced life chances both for students from disadvantaged backgrounds and for engineering students (Panel of Fair Access to the Professions 2009; House of Commons 2009; David 2010). This was evident in the FE institution in this study, where the college was the safest place some students knew. The pastoral skills of the lecturers (and the technicians, Learning Support Assistants and other staff), and an ethos where 'you've got to praise them much more than you tell them off' created an environment where students were able to learn.

The lecturers' and secondary teacher's subject expertise and professional backgrounds in industry were important resources for their students. The National

Grid report 2009 found that a number of maths and science teachers were 'embarrassed by their lack of knowledge of engineering, and are unlikely to recommend engineering as a career. The exceptions are FE (Further Education) teachers who tend to have been engineers, and those teachers with family connections'. (National Grid 2009: 7). The background of one of the lecturers as an apprentice who worked his way up through the education system is likely to be important to the vocational students in the college, and may have contributed to the high level of educational aspiration indicated by the apprentices in the online survey.

The talented FE students interviewed were hungry for information about university engineering courses, qualifications and employment options. This went beyond simply the supply of brochures and the like, to personal contacts with 'other people who have been there' and exposure to HE environments. There was a noticeable difference in the attitudes of Antony, who had had exposure to a university environment, and Mike who had not. Of these two talented vocational students, Antony felt comfortable and optimistic contemplating progression to undergraduate and indeed postgraduate academic work. Mike, equally talented, had completed his compulsory schooling abroad and entered the UK educational system at FE level. Although equally definite about attending university, he was less familiar and consequently, it appeared, somewhat more apprehensive about what university would actually be like. The college does organise contacts and visits to universities for their students, and it is clear that the more exposure the better.

In terms of external enrichment and support, the secondary students appeared to enjoy a better deal than the FE students. This was no doubt due in part to the unusual level of funding, effort and attention surrounding the development and launch of the Specialist Diploma in Engineering. The FE students did not appear to have access to the e-mentoring provision taken up by several of the secondary students, or to the extensive menu of events, visits and speakers described by Tariq. Although the London Engineering Project includes two FE colleges among its partner institutions, and invites FE students to activities, some of the provision appears to be focused toward A-level rather than vocational students. It is likely that logistical difficulties – and the constraints of an underfunded sector –make it difficult for FE students and lecturers to take advantage of these opportunities. Despite its importance in the education of young people from disadvantaged backgrounds, and its potential to foster social mobility, further education remains something of a 'Cinderella sector'.

A number of structural constraints to optimal learning were identified by the teachers. In secondary schools these included:

- fewer resources focused on redressing deficits in numeracy than literacy and English-language proficiency
- a concentration on the C–D borderline rather than on the needs of brighter students
- a lack of challenging maths provision for talented students who take GCSEs a year early.

From the students' point of view, both Carlos (at secondary level) and Kate (at Access level) regretted that schools and colleges seemed to expend more effort on students who don't want to learn than on those who do.

At college level, contextual constraints included the often very difficult financial and personal circumstances of the students, the inconsistency and intransigence of benefits offices withdrawing Job Seeker's Allowance from students 'trying to better themselves' by studying, and the tendency of Connexions offices to focus on disruptive young people, rather than providing good careers advice to those who want it. In its *New opportunities* White Paper the previous government expressed the intention to support young people to remain in education or employment in order 'to gain the better jobs that the global economy is generating – and make a significant stride towards the goal of increased social mobility (HM Government 2009: 66). It is likely that the new government will share these objectives. Yet the reports from the FE lecturers indicate that the benefits offices of some talented FE students put barriers in the way of these young people continuing with their studies. The rules for Jobseekers' Allowance are applied so inflexibly that talented learners are required to abandon their substantive studies in order to attend generic, low-level workshops on how to write cvs or do interviews.

Transition to Higher Education

The London Engineering Project has identified the critical importance of the transition from post-16 to university education. This transition is particularly crucial, and particularly challenging, for vocational learners seeking to enter higher education via Access courses. For this reason, the reports of the higher education lecturers involved in preparing Access students for university degree programmes in engineering are alarming. Both academics felt that a one-year Access course provided insufficient time for students to prepare effectively for 'an intense BEng course'. Despite the best efforts of the college lecturers, many vocational students arrived on the Access course with insufficient knowledge of maths and underpinning theory. In turn, the college lecturers reported, students arrived at the college with insufficient levels in numeracy and literacy.

As these reports illustrate, in areas of social and educational disadvantage, learners' gaps and deficits in mastering content can be shunted through the phases with successive teachers struggling to remediate them. For many learners Access courses such as the one in this study, where vocational pathways are intended to catch up to academic pathways, are tipping points. Talented learners such as Kate or Scott can, with determination and the right support, redress earlier deficits and catch up. Yet, as David reported, there are a number of learners of good potential who are lost. This illustrates the limitations of some widening participation efforts which purport to provide equal preparation, but instead supply too little, too late, and offer students 'false hopes'. It is to be hoped that the 'pupil premium' slated to be introduced by the incoming government is targeted at preventing the educational gaps being entrenched in the earliest phases, so that greater equity in preparedness for higher-level work is established.

Mathematics is unquestionably the domain of a number of 'threshold concepts' necessary to progress in engineering (Meyer and Land 2003). Scott, for example, admitted to having difficulty with 'complex numbers…when you start to get imaginary terms and real terms.' Both university and further education lecturers complained that students were entering their courses with insufficient levels of mathematics. Clearly students' gaps and difficulties start in primary or secondary school and are shunted on from one phase to the next. As this study reveals, problems with proficiency in mathematics create problems not only in terms of students' shaky confidence and the effective formation of the next generation of engineers. There is also a critical issue of social justice at stake. Without a sufficient grasp of mathematical (and other theoretical) principles, students who, despite disadvantages, progress to Access level or degree level through a vocational route, are being 'given false hopes' and set up to fail.

Issues in the standards of teaching and learning mathematics in this country are complex, longstanding, and well known. It is clear that efforts must continue to 'keep the door open' to higher-level mathematics as a crucial prerequisite for advanced positions in engineering, even in adult learning, and to improve maths teaching and learning at school. It is outside the scope of this study to offer detailed recommendations, and indeed this issue is the subject of expert attention from a variety of organisations, including universities, the Royal Academy of Engineering, the National Centre for Excellence in the Teaching of Mathematics and other professional bodies, various governmental task forces, and research teams sponsored by the Nuffield Trust. Neither of the university lecturers interviewed felt that a one-year Access course was long enough for students' mathematical deficiencies to be redressed and a successful transition to degree-level studies established. What is clear is that without solutions that effectively address this issue, this type of 'too little, too late' 'bridging' provision offers little more than lip-service to genuine widening participation.

The role of industry

An area identified for improvement by both teachers and learners was the lack of effective involvement with industry and employers. Richard summed up the further education lecturers' frustration with the difficulties involved in organising links with employers, calling it 'an absolute travesty' and 'the one thing that really pains me.' While Tariq, the secondary teacher, did not identify problems in this area, this may be somewhat unusual, and due possibly to his close involvement with the piloting of the Specialist Diploma. It might be conjectured that many secondary schools experience these issues also. Sandra, the university lecturer, also raised the problem, suggesting that a university liaison officer be specifically dedicated to forging relationships between the university and the engineering sector. From the students' perspective Luke expressed disappointment that neither the college nor the university had been able to organise a placement for him. More widely among the interviewed students, the power of authentic pedagogy and problem-based learning, cited by virtually all the students and teachers interviewed, would take on new momentum if there were actual businesses and business problems involved.

Ed, the FE lecturer, understood that hard-pressed businesses 'haven't got the time or the money to spare having to nurture someone for a couple of weeks [on a work placement]. It gets in the way of bottom-line profits.' He felt that 'it would be nice if the government could set up some small, genuine real businesses, non-profit-making businesses [where] you could spend the entire year having a turnover of [students] working…some real hands-on stuff and some real business.' Richard also yearned to see better links with employers. 'For example, the BTEC National Diploma has a year-long project. Some employer involvement [in this] would be fantastic.'

Recommendations

Efforts to provide meaningful, authentic learning routes for non-traditional and disadvantaged learners to enter engineering should continue. These might include using the 'pupil premium' to strengthen provision in mathematics in primary and secondary school, so the gap between disadvantaged learners and others is not allowed to become established. The Specialist Diploma should continue, and efforts put in place to cascade good practice such as that demonstrated in the case study partnership, to other schools. The complexities and difficulties of doing so, including tackling the shortage of engineering teachers in secondary schools, are not discounted. Nevertheless, the key scarce resource in schools and colleges – time – should be prioritised, and bureaucratic barriers removed, in order to establish good working relationships between schools, where specialist knowledge and industry-sector experience are scarce, and FE colleges, where they exist.

In the meantime, attention should be given to the issue of the shortage of time on university Access courses, which currently are too hurried to establish effective grounding for students in core mathematical and theoretical principles. Apprenticeship Scholarships to higher education should be investigated as an additional route into engineering for motivated, talented students, with attention paid to what lessons might be derived from the success of Foundation Degrees.

The key role of further education should be enhanced with additional time, resources and external support. The enrichment benefits associated with the launch of the Specialist Diploma in Engineering, such as the London Engineering Partnership's e-mentoring scheme and access to events and guest speakers, could be distributed further into the FE sector, and in any case might be rolled out further across the country. In turn, the expertise and experience of further education lecturers in engineering might be harnessed for outreach activities into secondary and primary schools. This could form a branch of an revived careers advice service, long overdue for reform and improvement.

The policies and practices of benefits offices should be reviewed and reformed, so that education of committed learners does not founder on the threat of withdrawal of benefits and they are not forced to 'end up in some silly little job somewhere.'

The quality and quantity of work experience is critical as an aspect of engineering education. Measures should be explored for widening the contact base and support for arranging meaningfully, mutually productive work experience and placements for students in secondary, and especially further and higher education.

Mathematics is both crucial to learning and progression in engineering and, as this study indicates, problematical to vocational learners. Many of the underlying factors for the limitations in mathematics education, such as the dearth of qualified teachers, are systemic and longstanding. It is assumed that government policy will continue to address this, for example in retaining recent increases of university places in mathematics and additional funding for trainee teachers in mathematics. The high-quality and proactive efforts to promote mathematics education by professional and educational bodies such as the Royal Academy of Engineering need to continue and garner support from a wide range of partner organisations and agencies, especially those that can make the biggest impact in schools.

The Stephen Lawrence Charitable Trust already supports the improvement, accessibility and enjoyment of mathematics provision for young people through its Youth Creativity and Urban Design programme, for example in hosting and sponsoring robotics workshops and competitions. It is to be hoped that these activities will continue to offer young learners, from primary to further education, exciting opportunities to explore for themselves the links between mathematics, engineering and occupations in the built environment at all levels. If measures are not already in place to do so, co-ordination, collaboration and joint learning between Trust and other bodies making efforts in this area, such as the Royal Academy of Engineering, the Brightside Trust, the London Engineering Partnership, and the National Grid, would optimise the returns on these efforts.

The barriers and constraints surrounding many of these recommendations are not underestimated. Yet it is to be hoped that with the help of progressive and optimistic organisations and public services, ways may be found to create synergies that contribute to the ongoing project of building the future for all talented engineering students.

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Appendix 1: Online survey questions

About this survey

This survey is part of a study that Oxford Brookes University is doing for the Stephen Lawrence Charitable Trust. The study is about engineering students in FE colleges. You can find out more about it by reading the information sheet your teacher gives you.

Your consent

You do not have to do this survey if you don't want to. If you agree to do this survey, click the 'I agree' button in the next question.

1. The information I give in this survey can be used in the study for the Stephen Lawrence Charitable Trust.
   - I agree
   - I don't agree

2. My student number is:

3. My age is:
   - 14-16
   - 17-19
   - 20-29
   - 30-39
   - 40 or over

4. The previous qualifications I gained at school are:
   - 5 or more GCSEs at grade C or above, including Maths and English
   - 5 or more GCSEs at grade C or above, not including Maths and English
   - 3-4 GCSEs
   - 1-2 GCSEs
   - No GCSEs
   - Not relevant, as I'm still in school
   - Other, please specify

5. My gender is:
   - Male
   - Female

6. My ethnic background is:
   - Indian
   - Pakistani
   - Other Asian/Asian British
   - Black/Black British: African
   - Black/Black British: Caribbean
   - Other Black/Black British
   - Chinese
   - Mixed White/Asian
   - Mixed White Black African
   - Mixed White/Black Caribbean

- Other Mixed heritage
- White British
- White Irish
- Other White
- Other

7. I am currently:
- doing an Engineering Specialist Diploma for school
- doing an Engineering Level 1 NVQ course at College
- doing an Engineering Level 2 NVQ course at College
- doing an Engineering Level 3 NVQ course at College
- doing an Engineering BTEC National course at College
- doing an Engineering Access course at College
- Other, please specify

8. I'm an apprentice:
- Yes
- No

9. After my course is finished, what I'd most like to do is:
- find a job in engineering
- find a job not in engineering
- study engineering to a higher level in college
- go to university to study engineering
- go to university to study, but not engineering
- continue working in engineering
- continue working not in engineering
- continue working as an apprentice in engineering
- Other, please specify

10. I decided to do this course because: (Please rank the answers in order of importance, with 1 being most important and 7 least important.)
- someone in my family is in engineering
- a friend is doing a course of works in engineering
- it will help me get a job
- I like the maths
- I like the problem-solving
- I like knowing how things work and being able to fix them
- I like practical, hands-on work

11. Have you ever had work experience or been employed in engineering?[*]
- Yes
- No

12. If yes, choose the number of people who work in the company:
- 1-10 employees

[*] Questions 11 to 14, on employment or work experience in engineering, were misunderstood by the majority of respondents, so the survey results are likely to be somewhat unreliable and have not been considered in the Survey Findings section of this report. For example, 24% of respondents (n = 22) answered Yes to having had work experience, and 76% answered No (Question 11). However, 93 respondents answered Question 13, which should only have been answered by the 22 individuals who had answered Yes to Question 11.

- 11-25 employees
- 25-50 employees
- over 50 employees
- don’t know

13. I heard about this work experience / job through:
- family
- friends
- school/college
- faith group or community contact
- Job Centre
- Advert
- Other, please specify

14. Who helps you most when you need to understand something hard in your course? (Please rank the answers in order of importance, with 1 being most help and 6 least help.)
- my friends
- other students
- my family
- my teachers and tutors
- my work mates
- figuring it out by myself

15. Who encouraged you the most to do this course? (Please rank the answers in order of importance, with 1 being most encouragement and 6 least encouragement.)
- careers adviser
- friend
- teacher
- family member
- faith group or community contact
- other

16 The part of the course I am best at is:

17 The part of the course I am worst at is:

18 The part of engineering I like best is:

19 The part of engineering I like least is:

20 If I could choose any job, I would most like to:

Appendix 2: Interview questions for students

Preliminary questions and discussion

Restate the purpose of the study
Stress anonymity of answers. Recheck permissions:

- Have you read the information sheet?
- Are you happy to give us permission by signing the consent form?
- (For secondary students) Have your parents read the information sheet? Are they happy to give permission for you to participate, and have they signed the consent form?
- OK to tape the interview?

1 Did you do the online survey here at the college last December? It would help us understand what you say in the interview better if we could see it in relation to what you said in the online survey. Is this OK with you? If so, please can you tell me your student number, and we can find your survey responses.

2 Can you tell me a little about yourself please?
[eg prompt for: How old are you? What year are you in at school? How long have you been going to this school? How long have you lived in London?]

Theme 1: attitudes to the subject

3 Why did you decide to study for the Engineering course you're on?

4 If you could have a look at the grid and tell me a bit about which parts of the course:

- you like the best
- you like the least
- you find easy
- you find hard

[prompt for reasons; motivating and demotivating factors; and to see whether they always dislike the hard parts, and like the easy parts, or whether their views are more mixed]

5 What do you think you need to understand or practise to be good at engineering?
[eg subject areas, motivation, practical skills, types of thinking, etc]

Theme 2: what they find helpful in teaching and learning

6 I understand that on your course there are teachers from the school and/or the college, technicians, and learning assistants (for secondary students).
How do these people help you, and why?

7 What kinds of things help you learn best?

Theme 3: sources of support

8 Do you do any engineering activities outside school/college?

9 Is there anyone who helps you outside of school and/or college?
[eg any family, friends, etc, in engineering?]

Theme 3: plans and aspirations

10 What would you like to do after you finish your Diploma/course, and why?
[educational plans, employment, etc]

11 What kinds of information or advice might help you make plans for the future?

Theme 4: advice for schools / teachers / family

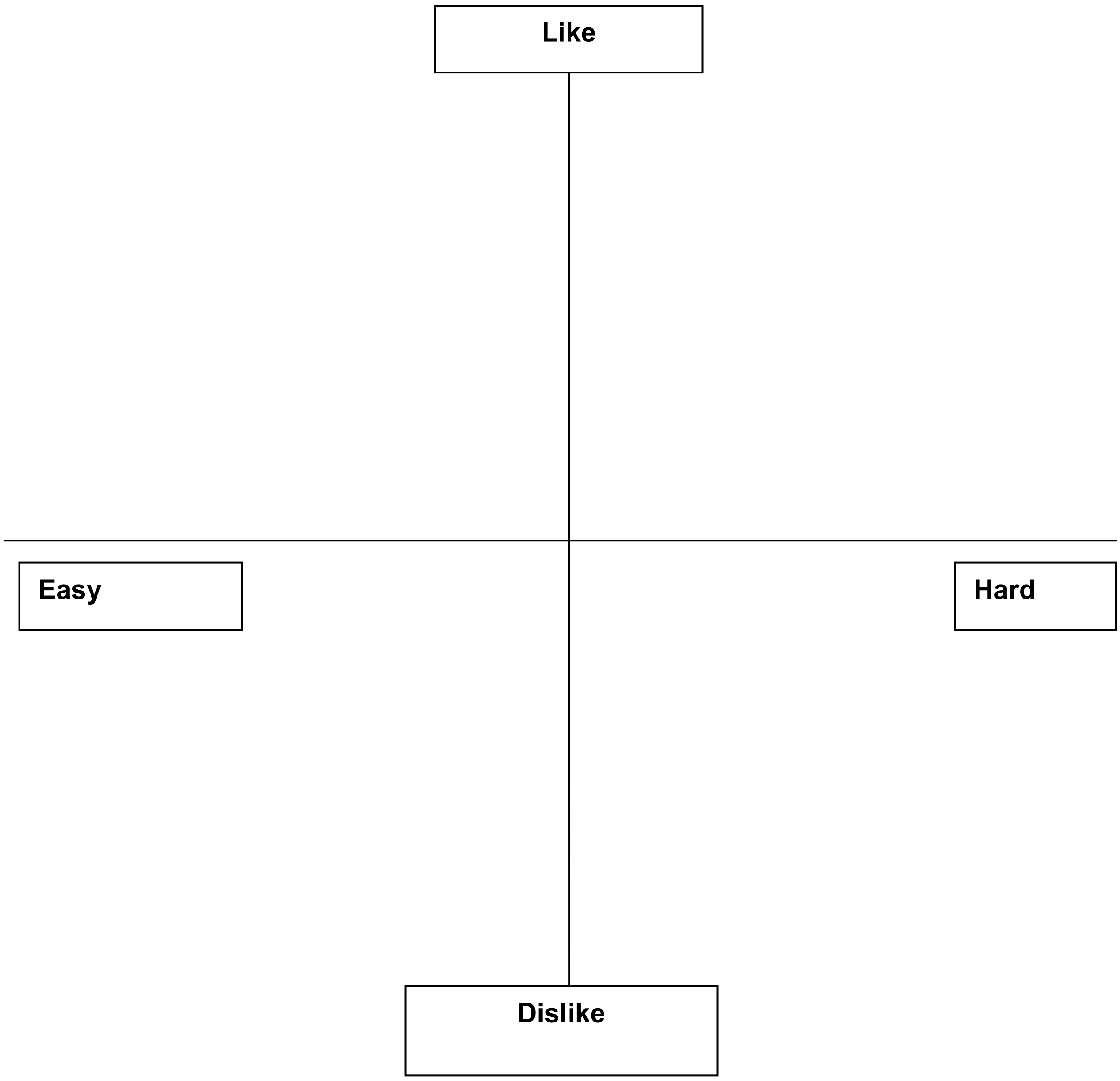
12 If you think back to when you were in primary school, what did you find useful in helping you get interested in engineering-type things?

13 What kinds of things in secondary school helped your interest in engineering?

14 Is there anything more that secondary schools could do to help kids learn about engineering?
[eg, for secondary, anything in Years 7-9, before they get to the Specialist Diploma; for FE, anything from secondary experience]

15 What can parents, families or carers, do to help kids get good at engineering?

16 Is there anything else you can think of that would be helpful?


Like
Easy
Hard
Dislike

Appendix 3: Interview questions for teachers

‘Building the Future’ study for the Stephen Lawrence Charitable Trust
Interview schedule for FE lecturers

Note: Versions of this interview schedule were adapted and contextualised for interviews with the secondary teacher and the higher education lecturers.

The SLT has asked us to focus on engineering lecturers and students because they believe this area is a suitable proxy for technical and vocational subject areas leading to proficiency and employability in the built environment and urban design.

Interview questions are centred around 5 themes:

- The teachers’ conceptions and implicit theories of high potential/high ability in engineering
- How they recognise this in their students
- How they develop and nurture talent in their students
- What types of support, advice and guidance such students need
- Progression routes and trends among their students

Preliminary questions and discussion

Restate the purpose of the study / research
Recheck permissions
Inform them of their right to check the notes of their responses for factual accuracy, and inform us if they’d like changes made. This opportunity occurs before report-writing stage.

1 What courses do you teach in the college?

2 Can you tell me something about your background as a lecturer in the college?
[Probe for how long, experience in other institutions, in industry, etc]

Theme 1: conceptions and implicit theories of high potential/ability

3 When you think of the students you nominated as having high potential or being ‘able’, which characteristics come to mind?

4 From your experience, which kinds of characteristics, if any, do able engineering students share?
[Use KAMIS model to probe this, by listing the categories in the model and asking lecturers to flesh out what this looks like in their students – if it does. They can also dispute or reject the model or its elements.]

Theme 2: identifying / recognising high potential/ability in their students

5 What indicates to you that a student has the potential to achieve particularly successful outcomes in their engineering course?

6
a) How long do you think it takes you to recognise high potential in a student?
b) How long, in your view, does it take a student to realise that they might have this potential?

7 In your view, what factors might account for a student with high potential failing to turn this into high attainment or performance?
[Probe as to personal support networks and background, education factors, elements of the KAMIS model]

8 What factors account for students with high potential fulfilling this potential?
[Probe as to personal support networks and background, education factors, elements of the KAMIS model]

Theme 3: developing and nurturing talent

9 What's the best way to develop an able student's talent in your area of engineering:

a) in the classroom? [probe for teaching & learning approaches; the balance between knowledge and skills based learning; key skills; the development of analytical / critical thinking that HEIs look for in students]

b) in the workshop? [probe for relationship /balance between knowledge and skills based learning; theory and practice]

c) in the college? [probe for additional support college might offer that help develop talent]

d) outside of college?

10 What's the best way to motivate students with this type of high potential?

11 Going back to what you identified as the characteristics of students with high potential in engineering, if you were advising primary schools on the best way to develop and support this type of potential in children, what would you tell them?

12 If you were advising secondary schools on the best way to develop and support this type of potential, what would you tell them?

Theme 4: types of support, advice and guidance such students need

13 In your view, which kinds of advice, support and guidance are particularly helpful in maximising opportunities for students of high potential?

14 In your view, which factors – beyond the successful completion of engineering programmes – are most likely to promote opportunities for students to become successful in engineering occupations?
[Prompt for issues such as role models, leisure activities, etc]

Theme 5: progression issues

15 Which destinations are most common for able engineering students when they leave college?
(Prompt: eg into employment, further training, HE, other types of work…)
[Probe: whether destinations necessarily correspond with ability or achievement outcomes]

16 What are the factors influencing able students going to these destinations?

17 In your experience, what are the main attributes making students attractive to employers in the engineering sector?

18 Are there any factors that particularly help or hinder the development of these attributes in students?

Appendix 4: Progression routes in Engineering

The University engineering access students interviewed in this study all had conditional places to study engineering at prestigious universities. If successful, they will probably progress to becoming Chartered engineers.

The secondary school pupils interviewed were only 14-16 and therefore it was too early to say if they would take this route, a less professional route into engineering, such as a route leading to technician status, or indeed follow a career route unconnected with engineering.

There are three main levels of engineering: Chartered engineer, Incorporated engineer, and Technician engineer. A useful website for those interested in exploring a career in engineering is: http://www.enginuity.org.uk from which the following information has been taken.

Graduates with accredited degrees and experience of working in appropriate roles are encouraged to apply for registration as an Incorporated or Chartered Engineer. For entry onto an accredited engineering degree (see the Accredited Courses Database at
http://www.engc.org.uk/registration/acad/search.aspx)

students usually need: A Levels, or the equivalent, in mathematics and – depending on the discipline – physics and/or chemistry and design & technology. They also are likely to need GCSEs (grades A* to C) or equivalent including mathematics, English, and sciences.

Those without an accredited degree but with extensive relevant experience can also apply to become an Incorporated or Chartered Engineer through an individual assessment. Would-be engineers can also enter Higher Education by taking a foundation degree (see www.fdf.ac.uk for details) or, for example, HNC, HND or through a Higher Apprenticeship route.

A key route for Engineering Technicians is to take Advanced Apprenticeships (England and Northern Ireland) or Modern Apprenticeships (Scotland and Wales). These lead to qualifications such as N/SVQ3, technical certificates and core skills and combine studying with employment. For entry into apprenticeships applicants will generally need a minimum of five GCSEs, including English, mathematics and science or technology subjects, often at A* to C because there is very strong competition for places. Young Apprenticeship completion is usually strongly welcomed for entry to Advanced Apprenticeships and Higher Diplomas (in England) may also be welcomed. More mature applicants are also strongly welcomed.

The equivalencies of the BTEC qualifications according to the Government's Achievement and Attainment Tables are:

BTEC Introductory Diploma = 4 GCSEs D-G
BTEC Introductory Certificate = 2 GCSEs D-G
BTEC First Diploma = 4 GCSEs A*-C
BTEC First Certificate = 2 GCSEs A*-C
BTEC National Award = 1 GCE
BTEC National Certificate = 2 GCEs
BTEC National Diploma = 3 GCEs
Apprenticeships usually comprise a Technical Certificate
(e.g. a BTEC qualification) Key Skills and an NVQ.

LEVEL	BTEC Qual	BTEC Short course	GCE Applied A level	Applied GCSE	NVQ
E	BTEC Entry Level Certificate in Skills for Working Life (Practical Skills)				
1	BTEC Introductory Diploma and Certificate in Engineering				NVQ in Performing Engineering Operation
2	BTEC First Diploma and Certificate in Engineering			GCSE in Engineering GCSE in Manufacturing	NVQ in Performing Engineering Operations
3	BTEC National Diploma and Certificate in Engineering		GCE in Engineering		NVQ in Marine Engineering Operations

Level 4 Engineering qualifications:

University Degrees (Most universities recognise BTEC National awards, but e.g. Imperial does not**)**, BTEC Higher National Diplomas, BTEC Higher National Certificates, Foundation Degrees, BTEC Professional Qualifications, Professional Qualifications, NVQs 4/5

Some examples of qualifications for careers in Engineering and Technology
http://www.enginuity.org.uk

Levels 1 and 2
England, Wales and NI:
§ GCSE Science
§ GCSE Additional Science
§ GCSE Additional Applied Science
§ GCSE Applied Science (Double Award)
§ GCSE Biology, GCSE Chemistry, GCSE Physics (‘Triple Science’)
§ GCSE Maths

§ BTEC First Certificate in Applied Science
§ BTEC First Diploma in Applied Science
§ OCR National (level 2) Award Science
§ OCR National (level 2) Certificate Science
§ City and Guilds (Level 2) e.g. Certificate in Engineering, Engineering Maintenance

Scotland:
§ Standard Grade Biology, Maths, Chemistry and Physics

Level 3

England, Wales and NI:
§ GCE AS and A level Biology, Maths, Chemistry and Physics, Further Maths
§ GCE AS and A level Applied Science (single and double awards)

§ BTEC National Awards in Biology, Maths, Chemistry and Physics
§ BTEC National Certificate in Applied Science
§ BTEC National Diploma in Applied Science
§ City and Guilds (Level 3) e.g. certificate in Aeronautical Engineering

Scotland:
§ Higher and Advanced Higher Biology, Maths, Chemistry and Physics

Vocational
A wide range of National Vocational Qualifications (NVQs) and Scottish Vocational Qualifications (SVQs) are available at levels 1, 2 and 3.

Apprenticeships
In England:
§ Young Apprenticeships (appropriate for Key stage 4)
§ Apprenticeships
The framework contains NVQ level 2 and a technical certificate such as BTEC First Certificates and Diplomas and
§ Advanced Apprenticeships
The framework contains NVQ level 3 and a technical certificate such as BTEC National Certificates and Diplomas
These are available in several areas of engineering and other sectors.

Diplomas
In England, new Diplomas at Foundation, Higher and Advanced level:
§ Construction and the Built Environment
§ Engineering
§ IT

Baccalaureates
§ International Baccalaureate
§ Welsh Baccalaureate (foundation, intermediate and advanced)
§ Scottish Science Baccalaureate is being developed

Appendix 6: Engineering education websites

Brightside Trust (2008) Live Journals - for the future of engineers in Britain (e-mentoring for engineering project): London: Brightside Trust.
http://www.thebrightsidetrust.org/viewproject.php?pid=15
(accessed 25 August 2009)

Enginuity (2009) Enginuity website. London: Engineering and Technology Board Limited (ETB):
http://www.enginuity.org.uk/
(accessed 26 August 2009)

Institute of Civil Engineers (ICE) (n.d.) Education Zone. London: ICE Education & Learning:
http://www.ice.org.uk/education/homepage/index.asp
(accessed 26 August 2009)

London Engineering Project (LEP) (2008-9) London Engineering Project. London: Royal Academy of Engineering:
http://www.thelep.org.uk/home
(accessed 25 August 2009)

Qualifications and Curriculum Development Agency (2007) Engineering: Curriculum Guidance for the Diploma. London: Qualifications and Curriculum Authority:
http://www.qcda.gov.uk/13483.aspx
(accessed 25 August 2009)

Royal Academy of Engineering (2009) Mathematics for Engineering: An ASL Qualification for the Advanced Diploma in Engineering. London: Royal Academy for Engineering
http://www.raeng.org.uk/education/diploma/maths/default.htm
(accessed 25 August 2009)

Science, Engineering and Manufacturing Technologies Alliance (SEMTA) (2008) The Diploma in Engineering. Watford: SEMTA.
http://www.engineeringdiploma.com/
(accessed 25 August 2009)

National Centre for Excellence in the Teaching of Mathematics (NCETM): STEM interest group
http://www.ncetm.org.uk/search?q=STEM
(accessed 20 October 2009).