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BCS, The Chartered Institute for IT

in association with the UK Computing Research Committee (UKCRC)

and the Council of Professors and Heads of Computing (CPHC)

Consultation Response to:

House of Lords Science and Technology Sub-Committee 1
Call for Evidence on Higher Education in STEM Subjects
Dated: 12 December 2011

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BCS, The Chartered Institute for IT

The Institute promotes wider social and economic progress through the advancement of information technology science and practice. We bring together industry, academics, practitioners and government to share knowledge, promote new thinking, inform the design of new curricula, shape public policy and inform the public.

As the professional membership and accreditation body for IT, we serve over 70,000 members including practitioners, businesses, academics and students, in the UK and internationally. We deliver a range of professional development tools for practitioners and employees. We accredit almost all University Computer Science degrees in the UK. A leading IT qualification body, we offer a range of widely recognised professional and end-user qualifications.

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Council of Professors and Heads of Computing

The Council of Professors and Heads of Computing exists to promote public education in Computing and its applications and to provide a forum for those responsible for management and research in university computing departments. CPHC represents the interests of a membership engaged in the management of University Computing education and University Computing research within the UK Higher Education sector. We are an independent body, registered as a charity, and, although we work closely with all the Professional and Statutory organisations relevant to our sector, we are not affiliated to any other body.

CPHC is recognised as the Subject Body for Computing by the Funding Councils and by QAA, and it works in conjunction with UKCRC to address research issues with the Research Councils, particularly EPSRC.

http://www.cphc.ac.uk

UK Computing Research Committee

The UK Computing Research Committee aims to promote the vitality, quality and impact of Computing Research in the UK. Its members are internationally leading computer researchers drawn from both academia and industry. The UKCRC was formed in November 2002 and is an Expert Panel of the British Computer Society, the Council of Professors and Heads of Computing and the Institution of Engineering & Technology.

By contributing to policy formation within these three key national bodies, UKCRC enables UK Computing Research to speak with a single voice. UKCRC presents its views to Government, Parliamentary Committees and other agencies through pro-active submissions and responses to consultations.

http://www.ukcrc.org.uk

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General questions

What is the definition of a STEM subject, and a STEM job?

1. Computer Science is a core STEM subject as it combines the methodologies of science, engineering, technology and mathematics. Computer Science plays a major role in all employment sectors, e.g., finance, entertainment, academia, health, retail, education, defence, government, etc. For example, pharmaceutical companies such as GlaxoSmithKline require interdisciplinary teams of professionals working at the boundary of biology, physics, chemistry, pharmaceutics, numerical analysis and computer science. In fact, almost every sector has been transformed by the application of computers and computational thinking. Our conversations with global technology companies, start-ups in London's Tech City, Tier One Banks in the City and leading computer games companies suggest there is a severe shortage of people with deep expert Computer Science knowledge who also understand how to apply that knowledge to create business value.

2. Unfortunately, Computer Science has not been recognised as one of the STEM subjects identified as "strategically important and vulnerable subjects". In view of both its strategic importance to the UK's economy and the under-supply of Computer Science graduates, this anomaly should be corrected as soon as possible.

3. Many advances in Science and Engineering of recent times have only been possible because of accompanying advances in Computer Science; for example the Human Genome Project[1], Large Hadron Collider[2,3], predicting climate change[4], epidemiology[5], Airbus fly-by-wire[6] and electric hybrid vehicle development[7].

Do we understand demand for STEM graduates and how this could be used to influence supply?

4. Because of the rich and diverse employment opportunities for Computer Science graduates it is hard to fully understand employers' demand for them. e-Skills UK estimates[8] that the excess of demand over supply reaches its maximum in the Computer Science sector. They also estimate that there has been a steady increase in demand over the last decade, despite the dot.com bust, outsourcing and the current period of austerity. Outsourcing has, though, led to a proportionately higher demand for high-skilled Computer Science graduates. OECD data[9] shows

[1] http://www.lbl.gov/Science-Articles/Archive/human-genome-mapping-sequencing.html
[2] http://public.web.cern.ch/public/en/Research/DataAnalysis-en.html
[3] http://lcg.web.cern.ch/LCG/public/default.htm
[4] http://www.metoffice.gov.uk/climate-change/guide/science/modelling
[5] http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2004_02_06/noDOI.13665861607928732511
[6] http://www.airbus.com/innovation/proven-concepts/in-design/fly-by-wire/
[7] http://www.nytimes.com/2011/01/23/automobiles/23SPIES.html
[8] Technology Insights 2011 http://www.e-skills.com/research/research-publications/insights-reports-and-videos/technology-insights-2011
[9] OECD Information Technology Outlook 2010

that unemployment for IT professionals across the main 15 EU states has been less than 5% throughout the period 1998 to 2008.

5. Note that HESA employment statistics for Computer Science are misleading and over-estimate the true unemployment situation for Computer Science graduates. This is because degrees with very little Computer Science content are bundled with true Computer Science degrees when calculating the statistics. This error is harming the recruitment of students to Computer Science degrees and needs to be addressed as a matter of urgency.

6. Data from one representative UK University shows that 6 months from graduating 6.7% of CS graduates on non-sandwich courses were unemployed and 4% of CS graduates on sandwich courses were unemployed, based on a sample of 371 students over 5 years. Also, based on the 30% of 2010 CS grads for whom the starting salary was known, the starting salary on graduation for non- sandwich students was £20,754 whereas for sandwich students it was £26, 461. Note the median salary for men working full-time in 2010 was £28,400 according to the ONS.

16-18 supply

Are schools and colleges supplying the right numbers of STEM students and do they have the right skills to study STEM first degrees?

7. Computer Science (as opposed to digital literacy skills) is not being taught in enough schools nor to enough school students. As a result, universities are not able to assume any prior knowledge of Computer Science in their undergraduate intake. Mathematics is a key enabling skill for Computer Science undergraduates, but not enough students reach the necessary level of expertise. See

Appendix: Collapse in students taking GCE computing and GCSE *ICT*' for more details. The current ICT curriculum as taught in many schools has actively discouraged students from further study of IT or Computer Science. There were only around 4000 students in the UK taking Computing A level in 2010. There has been a decline of roughly 50% over the last six years of students taking Computing at GCE.

8. It is extremely welcome that the Coalition Government has recognised the need to reform the ICT curriculum[10]: "the Government recognises that learning the skills to use ICT effectively and acquiring the knowledge of the underpinning computer science are two different (albeit complementary) subjects. Furthermore, the Government recognises that the current ICT programme is insufficiently rigorous and in need of reform."

What have been the effects of earlier government initiatives on the uptake of STEM subjects at advanced level?

9. Governments have confused Computer Science and digital literacy. ICT curricula have focussed on the latter at the expense of the former. Acquiring skills at using office products has taken precedence over, for instance, learning to program. Students find this repetitive and boring. They gain a false impression of the nature of Computer Science and are put off pursuing it as a degree subject.

What effect, if any, will the English Baccalaureate have on the study of STEM subjects in higher education?

10. The exclusion of Computer Science as a recognised Science in the English Baccalaureate will exacerbate the problem of its low uptake in schools and negatively increase its uptake at degree level.

Graduate supply

Is the current number of STEM students and graduates (from the UK, EU and overseas) sufficient to meet the needs of industry, the research base, and other sectors not directly connected with STEM?

11. No. See earlier discussion of the excess of demand over supply in this sector.

Is the quality of STEM graduates emerging from higher education sufficiently high, and if not ,why not?

12. UK Computer Science graduates are generally recognised to reach a high standard of technical expertise.

Do STEM graduates have the right skills for their next career move, be it research, industry or more broadly within the economy?

[10] The Government's response to Next Gen. Transforming the UK into the world's leading talent hub for the video games and visual effects industries, ISBN: 9780101822626

13. Although they reach a high standard of technical expertise, Computer Science students do not always have the range of transferable skills required by industry, which includes entrepreneurial skills. BCS encourages the inclusion of transferable skills training in Computer Science degrees via its accreditation process. Note, however, that due to the diversity of employment opportunities open to Computer Science graduates and the diverse needs of employers in different sectors, a simplistic 'kite-marking' scheme for Computer Science degrees could have a negative effect. See 'Appendix: University initiatives to develop softer skills.' for some examples of good practice in universities.

What effect will higher education reforms have on the quality of teaching, the quality of degrees and the supply of STEM courses in higher education institutions?

14. The exclusion of Computer Science as a compulsory subject in both the new National Curriculum and the English Baccalaureate is likely to reduce further its uptake by school students. The situation in Scotland is healthier. The introduction of the Curriculum for Excellence has returned control over the curriculum to teachers, many of whom are keen to teach Computer Science as a STEM subject. The BCS Academy of Computing, in conjunction with the Royal Society of Edinburgh, is supporting this development by developing exemplary teaching materials for the first three years of secondary school.

What effect does "research assessment" have upon the ability to develop new and cross-disciplinary STEM degrees?

15. Computer Science is an inherently interdisciplinary subject. Not only does it employ the full range of STEM methodologies, but it also borrows methodologies from the humanities, such as Psychology, Linguistics, Philosophy and Sociology. In the other direction, computational thinking is employed by almost every discipline: affecting the questions they ask, the answers they seek and the theories they form. As a result, cross-disciplinary degrees, both STEM and non-STEM, are the norm in Computer Science departments. The 2008 RAE evaluated Computer Science outputs by their absolute significance, rather than just their contribution to Computer Science. We expect the REF to continue this practice, so that interdisciplinary research and teaching will continue to be promoted.

What is the relationship between teaching and research? Is it necessary for all universities to teach undergraduates and post graduates and conduct research? What other delivery model should be considered?

16. Computer Science is a fast developing subject and it is vital that Computer Science teaching keeps pace with these developments. Therefore, Computer Science teachers must remain in touch with current research developments. The best way to achieve this is for them to remain research active and to supervise postgraduate students. Good teaching also contributes to a stronger research culture by improving the quality and supply of local graduate students.

Does the UK have a sufficient geographical spread of higher education institutions offering STEM courses?

17. Most higher education institutions teach Computer Science as a degree subject and conduct Computer Science research. This has been witnessed, for instance, by the large number of Computer Science departments submitting to each RAE.

What is being done and what ought to be done to increase the diversity of STEM graduates in terms of gender, ethnic origin and socio-economic background?

18. Female employment in Computing is about 18% which, while higher than many other engineering subjects, is still unacceptably low. The problem arises both in our failure to enthuse girls at school-level and our failure to retain those females who are recruited to Computer Science degrees. Women in Computing and many other Computing-based organisations are trying to address this problem, but with only limited success so far.

Post-graduate supply

Is the current training of PhD students sensitive to the range of careers they subsequently undertake?

19. Most postgraduate courses now include a substantial element of transferable skills training to try to ensure that PhD students meet the requirements of employers.

Are we currently supporting the right number of PhD studentships to maintain the research base and are they of sufficient quality?

20. The supply of PhD funding is insufficient to meet the demand. This is especially true for the very high quality EU and overseas students, who are often ineligible for even the little funding that is available. EU and overseas students often stay in the UK both to enhance UK research and to contribute substantially to the economy.

What impact have Doctoral Training Centres had on the quality and number of PhD students? Are there alternative delivery models?

21. DTC can be an excellent way of both attracting high quality students and delivering high quality postgraduate education. They should, however, be just one element of a range of delivery models. For instance, DTCs can overload postgraduate supervisors within the DTC, but underload equally qualified supervisors in other institutions. Similarly, there will be potential supervisors within a DTC institution, whose research does not lie with the DTC area and whose expertise is not employed by the DTC. We especially regret EPSRC's withdrawal of project studentships. Not only did working within a project team provide valuable experience to PhD students, but it was a rare source of PhD funding open to EU and overseas students.

Should state funding be used to promote Masters degrees and is the balance right between the number of Masters degree students and PhD students

22. Many employers value MSc degrees highly and prefer MScs over PhDs for many jobs. So state funding of MSc degrees is vital for the economy.

What impact will higher education reforms have on the willingness of graduates to pursue a

research career?

23. Students are often reluctant to pursue postgraduate study when they have a substantial debt from their undergraduate studies. Increased undergraduate fees will exacerbate this problem.

Industry

What incentives should industry offer to STEM graduates in order to attract them?

24. PriceWaterhouse Cooper have estimated the increased lifetime earnings from a STEM degree to be about £250k. This is substantially more than an arts or humanities degree and second only to medicine, which requires a longer period of study. STEM education should be especially attractive as a route out of poverty for people from a deprived background, as STEM graduates are valued solely for the expertise they have acquired.

25. Industry can identify potential high quality employees by offering Summer internships and sandwich course placements. These are highly valued by students, who seem them both as a way to gain employment experience and transferable skills, and as route to employment.

What steps are industry and universities taking together to ensure that demand for STEM graduates matches supply in terms of numbers, skills and quality of graduates?

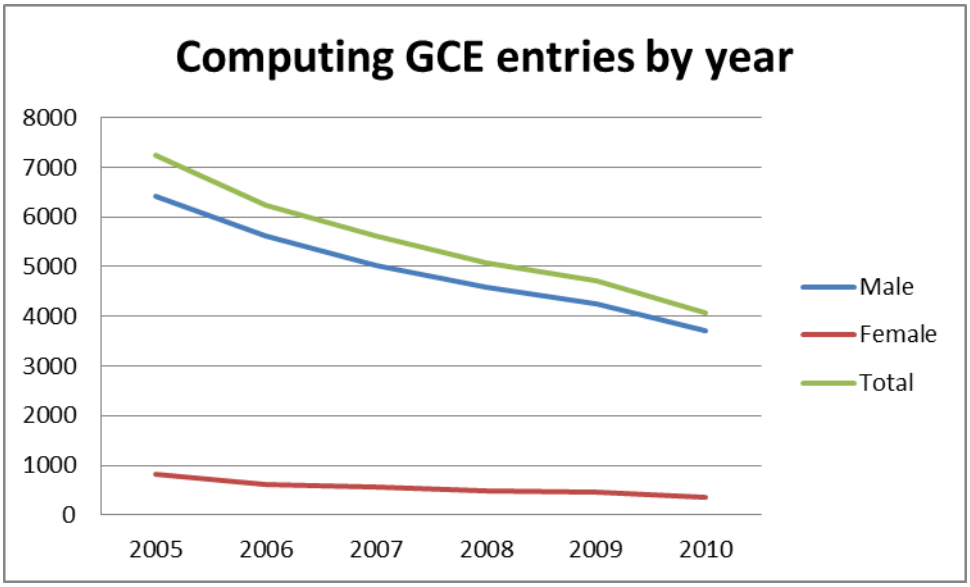
26. The BCS Academy of Computing have been working with Computing at School[11] (CAS), which is an organisation for Computing school teachers, to increase and improve the teaching of Computing in schools. CAS have over 1000 members covering over 800 schools in the UK. The BCS also accredits Computer Science degrees to ensure they meet the requirements of employers.

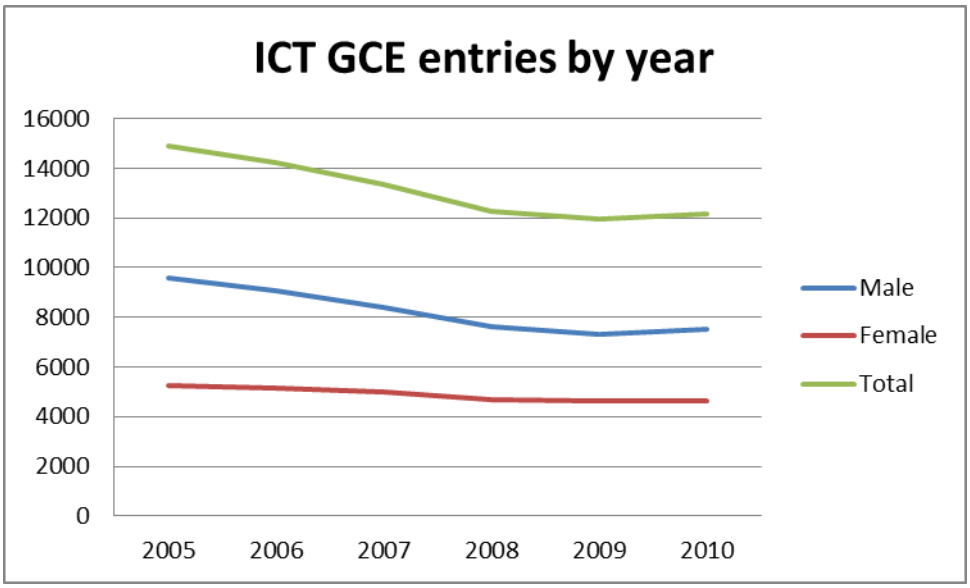
[11] http://www.computingatschool.org.uk/

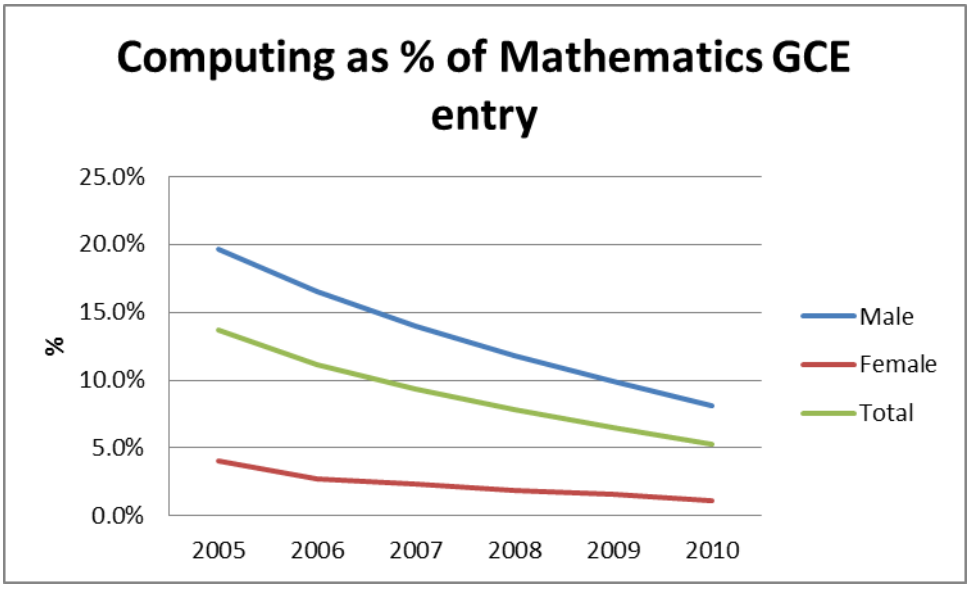
Appendix: Collapse in students taking GCE computing and GCSE ICT

27. The uptake of traditional Computing or IT qualifications has collapsed in English schools since 2001, as is demonstrated by the following statistics. The following text and illustrations are taken from the BCS submission to the Royal Society study on computing in school, http://www.bcs.org/content/conWebDoc/37945. It is included here for convenience.

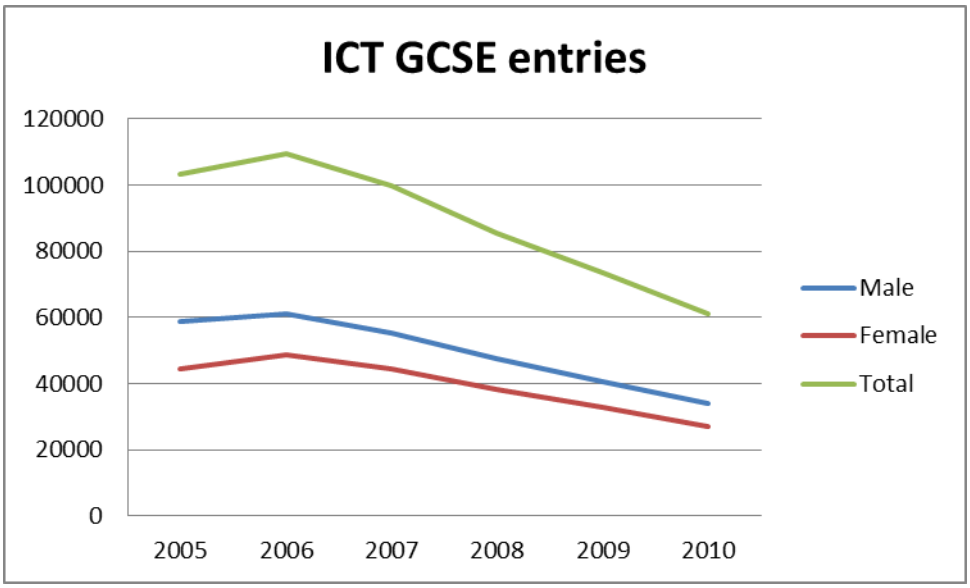
28. The following charts are based on the results published in June 2010 by the Joint Council for Qualifications. They indicate a decline of roughly 50% over the last six years of students taking Computing at GCE. In 2010 only about 5% took Computing compared to those taking Mathematics at GCE, indicating it is a subject in trouble, and not just attributable to decline in STEM subjects generally. Of particular concern is that the female entry for Computing GCE is only about 1% of the female mathematics GCE entry.

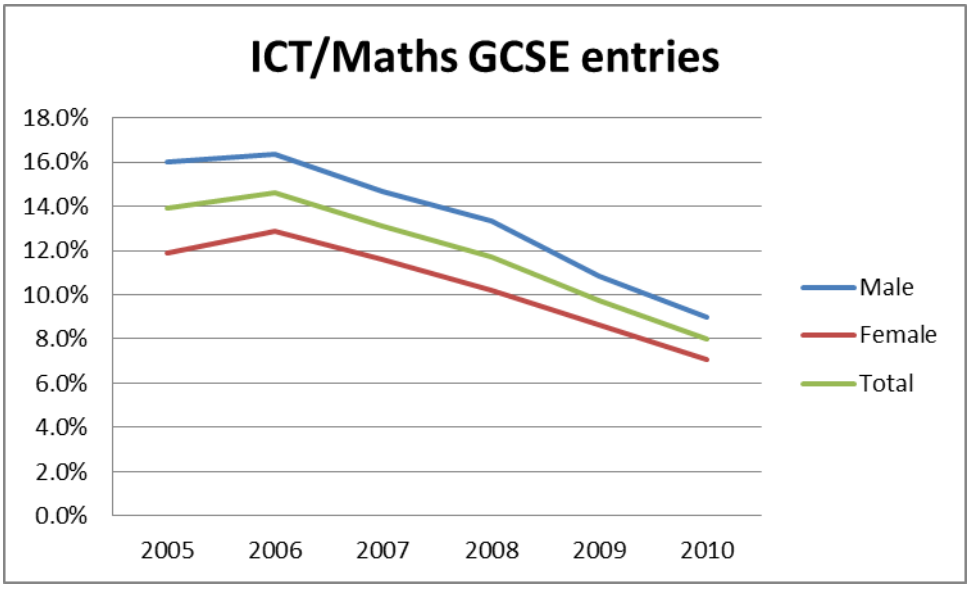






29. Looking at GCSE we see a similar decline in ICT entries (until 2011 there is no GCSE in computing). Note these graphs do not include GCSE equivalent qualifications, such as for example OCR Nationals or ECDL.





30. The overall picture for ICT across schools and FE is complicated by non-standard qualifications, or 'other' qualifications as described by Ofqual, which are qualifications other than GCE, GCE AS, GCSE and KS (Key Skills). Figure 1 shows comparative data from Ofqual[12] on 'other' qualifications ranging from Entry level to Level 3 (which is A2 level equivalent) from 2003 to 2009. The chart shows the number of students that passed `other' qualifications in each year. The vast majority of `other' qualifications taken in ICT shown here are at Level 1 or 2. The Ofqual figures do not just include schools, but also FE colleges and training providers. The chart includes some other subjects for comparison, where the double digit code against the subject name is the sector subject area code for that subject.

[12] Annual Qualifications Market Report 2010, Ofqual/10/4727

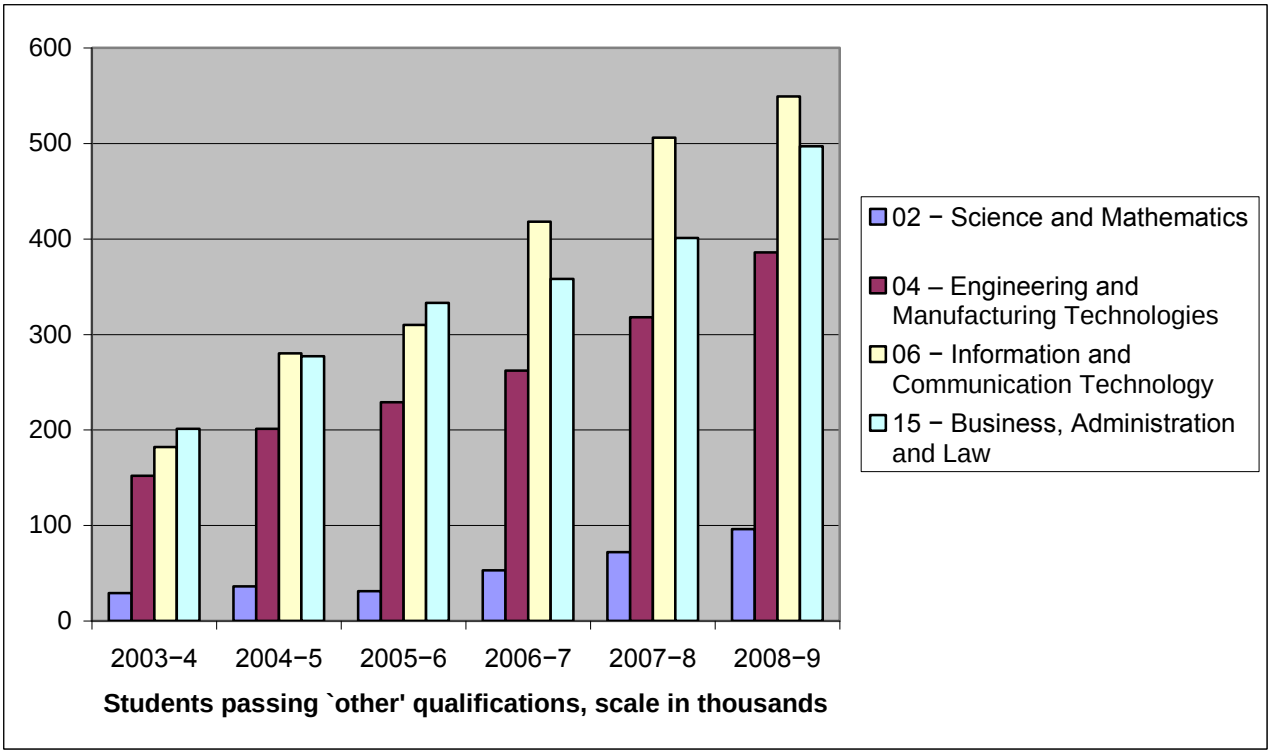


Figure 1: `Other' qualifications passed in England from Entry Level to Level 3

31. Figure 1 clearly shows that a great many students are gaining some kind of exposure to ICT from vocational qualifications throughout the 13-19 age range (around 550,000 in 2008/9). Across all subjects Ofqual report that Level 2 `other' qualifications are the fastest growing qualifications in England. The overwhelming majority of `other' ICT qualifications are designed to equip students with user skills and do not include a Computer Science component.

32. Some doubt had been cast on the value of some of these other qualifications compared to traditional GCSE qualifications by the Wolf Report on vocational education qualifications. Wolf Report P71: "*… many level 1 and 2 qualifications, including NVQs which are supposed to reflect workplace requirements, do not appear to have any positive outcomes whatsoever in terms of earnings and career progression. In other words, the content of many current vocational qualifications is not actually valued by employers and the labour market. Yet these qualifications form a major part of what is offered to 16-18 year olds*."

33. The new Diplomas are included in the `other' qualification category. They have not yet proven themselves to be a suitable vehicle for delivering a true alternative to A2 level. The new IT Diploma is still only being delivered in small numbers, in 2010 there were 540 Advanced IT Diplomas awarded. Ofsted have recently reported[13] that the `principal learning' component (which should correspond to the more academic content) of Diplomas in general is not delivered

[13] Ofsted, Diplomas: the second year, 2010

as effectively as is desirable in a third of the consortia providing Diplomas. Ofsted have also reported on other problems with Diplomas: "In addition, little evidence was seen of careful planning to help learners to rely less on the teacher and to develop progressively more independent ways of working and learning." The report also points out that "The separation of the teaching of functional skills from the 'principal learning' was an important weakness as the functional skills taught were not related to the vocational context of the 'principal learning'." This is a serious concern for Computing, since a lack of connection between the principles of Computing and how they are put into practice is likely once again to lead to an unacceptable learning experience for students.

34. The Wolf report also implicitly casts doubt on the value of the IT Diploma in some schools by including the following quote on P116: Head of the ICT Faculty at Cottenham Village College explained his preferred qualifications as follows:

"*We were running the Diploma in IT. We have abandoned it for two reasons.*

1. *It is 90% business and only 10% IT.*
2. *It is 90% report writing and 10% doing IT.*

There is a pretence that the Diploma in IT is hands on. But when one examines the mark schemes (which are, after all, the indicators of the value of each topic), one finds that less than 10% of the marks are given for doing IT work (building websites, creating databases, creating videos, etc.) and the vast majority of the rest of the marks are for writing reports on IT."

35. The conclusion is that there has been a continual steep decline since before 2005 in students taking traditional ICT qualifications at GCSE and GCE, which already lack a significant Computing component. At the same time there has been a steady rise in qualifications that are solely concerned with IT user skills at a functional level, which are delivered not just in schools but also in FE colleges and by private training providers. The system is now massively imbalanced in favor of IT user skills at the expense of Computing. There is also doubt over the value of some of these vocational qualifications with regards to providing a progression route to further study or a career.

Appendix: University initiatives to develop softer skills.

36. The following text is taken from the BCS response to the Wilson Review[14] and is included here for convenience. The ACM (the Association of Computing Machinery, the main learned society for Computer Science in the US) has identified that to compete in a global market computing and IT professionals need:

    - a firm grounding in the underpinning principles of Computing, which remain relevant even though particular technologies rapidly evolve and new ones are constantly being developed
    - to participate in life-long learning to ensure technology specific skills remain relevant
    - soft skills with regards to management, communication and collaboration across different companies
    - increasingly to become specialised within an application domain; e.g. pharmaceuticals, finance, telecommunications
    - to learn about technologies and management practices that underlie the globalisation of software; e.g. distributed workflow design and orchestration

37. There are many universities that include initiatives within their degree programmes that develop some of these additional softer skills. Two examples of good practice are given below.

38. Queen Mary are running ImpactQM, a three-year EPSRC funded KE project, to develop a new cadre of young academic scientists and engineers, who begin their research careers within a structured training framework that immerses them in both high performance research environments, and in organisations that will be of increasing importance to the UK's economy and society. Recent graduates include Kotub Uddin, a PhD student in the School of Mathematical Sciences. In 2010 he was awarded an ImpactQM scholarship to collaborate with Jaguar Land Rover where he used mathematical techniques to ensure optimal operation of co-operative systems involved in motion control in automobiles. Kotub has now joined the company. Jonathan Dunn, a PhD student working in synthetic organic chemistry used his ImpactQM scholarship to undertake a collaborative venture with Cancer Research Technology Ltd, where he worked on drug discovery projects. Rita Jorge, a PhD student in the School of Biological and Chemical Science who is working with the Government Office for Science on science policy projects. ImpactQM have been nominated in the "Outstanding Support for Early Career Researchers" category in the Times Higher Education Awards.

39. Another example is ProspeKT, which was run by Edinburgh University. ProspeKT was a partnership between Scottish Enterprise and the University to promote greater impact from the research within the School of Informatics. Funding was also obtained from the European Regional Development Fund to extend the Enterprise Creation element of the program to cover all of the Scottish Computer Science group. A follow on program, focussing on the Scottish Research Pool in Computer Science – SICSA, has just been launched funded by both SE and SFC. This program is called AspeKT.

[14] http://www.bcs.org/content/conWebDoc/42823

40. The program provided some 3 floors of space for commercial activity next to the School and a team of Business Development Execs to translate between business and the academic world. It has succeeded in driving a culture change within the School so industrial cooperation is now very widely accepted by the academic body, one major element here was having qualified Business Development staff to be able to screen and choreograph the relationships so the academics were not distracted by a large number of fruitless conversations. The concentration of high quality research within the School makes it an anchor site for inward investment, with presentation to companies brought in by UKTI and SDI. Visits have run at a rate of about 1 per week for extended periods of time and a number of local successes have been reported recently – the basing of Amazon's new support Centre and Avaloq's recent move to Edinburgh, both are worth some 500 jobs. The School also houses an Innovation Lab for EADS and recently a major US entertainment company has also taken space for an innovation studio. The School now has relationships with most of the global ICT players and a number of local technology based SME's.

41. The major success of the program has been the number of start-ups and spin-outs it has spawned – 37 in 5 years making it one of the most productive academic centres in the UK. Many of these companies are now trading internationally and a significant amount of seed funding (>£8.5M) has been raised despite the economic downturn. The survival rate of these companies is also quite string according to a recent BIS report. This also reflects a strong interest in the student base to build or work with a start-up when they graduate