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BCS, The Chartered Institute for IT

in association with the Computing At School group

Consultation Response to:

The Royal Society's Call for Evidence - Computing in Schools

Dated: 1 November 2010

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The "Computing At School" group (CAS) is a membership association run by BCS, The Chartered Institute for IT and supported by Microsoft Research, Google, Vital and other industry partners. It was created to support and promote the teaching of computer science and other computing disciplines in UK schools. Its membership is broad and includes teachers, examiners, parents, university faculty and employers.

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This Document

This document sets out the response of BCS, The Chartered Institute for IT, to the Royal Society's Computing in Schools Call for Evidence. The response has been prepared in close association with and considerable input from the Computing at School's group (CAS). BCS and CAS welcome and applaud the Royal Society's initiative in this important area. The numbered section headings in the response are taken from the questions in the call.

Fundamental Principle of Computing and ICT Education in Schools

Our response is guided by the following fundamental principle of Computing and ICT Education in Schools.

Schools must educate our children so that by the time they become adults they are capable of making intelligent and informed choices about the digital technology that underpins their world and they are capable of making valuable contributions to our digital society and economy. The purpose of ICT and Computing in schools is to equip every child with the basic understanding of computers and with the IT capabilities necessary to take their proper place in a digitally enabled, knowledge based society and economy.

1. Is computing a discipline, in the same way that mathematics, physics, chemistry are?

Computing is a discipline that, like maths or history, every student should meet at school.

A "discipline" is characterised by

- **A body of knowledge**, including widely-applicable ideas and concepts, and a theoretical framework into which these ideas and concepts fit.
- **A set of techniques and methods** that may be applied in the solution of problems, and in the advancement of knowledge.
- **A way of thinking and working** that provides a perspective on the world that is distinct from other disciplines.
- **Longevity**: a discipline does not "date" quickly, although the subject advances.
- **Independence from specific technologies**, especially those that have a short shelf-life.

Computing is a discipline with all of the characteristics set out above. It encompasses foundational principles (such as the theory of computation) and widely applicable ideas and concepts (such as the use of relational models to capture structure in data). It incorporates techniques and methods for solving problems and advancing knowledge (such as abstraction and logical reasoning), and distinct ways of thinking and working that are not shared by other disciplines (such as algorithmic thinking). It has longevity (most of the ideas and concepts that were current 20 or more years ago are still applicable today), and every core principle can be taught or illustrated without relying on the use of a specific technology.

Computing is a quintessential STEM discipline, sharing attributes with Engineering, Mathematics, Science, and Technology:

- Like mathematics it involves theory, logic, and reasoning.
- Like science it embraces measurement and experiment.
- Like engineering it involves design, construction and testing.
- And of course, without technology no computer program could run.

Moreover, Computing provides students with insights into other STEM disciplines, and with skills and knowledge that can be applied to the solution of problems in those disciplines.

Computing also has some distinctive differences. Natural science seeks to *discover*. Computing, more like mathematics, is a largely synthetic discipline: we seek to *create*. Natural scientists seek simple and widely-applicable "*laws*" that accurately predict the behaviour of the world, such as the inverse square law of gravitation. In computing we seek simple and widely-applicable *ideas or abstractions* that can be re-used again and again in different situations, such as divide and conquer algorithms, hierarchical naming structures, or caching. As Fred Brooks puts it "the natural scientist builds in order to study; the computer scientist studies in order to build".

2. Is programming a fundamental form of literacy for the modern age?

Programming empowers students to create new things through the powerful medium of computation, rather than simply to consume things made by others. This ability unleashes enormous creativity, and opens up whole new horizons of possibility. To get some sense of this diversity, look at the Greenfoot Gallery[1], or the Scratch Project gallery[2].

A basic understanding of programming is every bit as essential as the need for every child to understand and be competent with elementary mathematical algebra. Every child should understand algebra, be capable of abstracting appropriate problems into algebraic expressions and be capable of solving algebraic equations. In the same way, every child should be able to construct elementary algorithms in programmatic form that encapsulate simple ideas and concepts. Programming is a way of expressing creativity, of communicating and sharing ideas, just as mathematics is in a different area of discourse. Writing exact instructions is a fundamental skill.

Although they are invisible and intangible, software systems are among the largest and most complex artefacts ever created by human beings. The marriage between software and hardware that is

[1] http://greenfootgallery.org/
[2] http://scratch.mit.edu/

necessary to realize computer-based systems increases the level of complexity, and the complex web of inter-relationships between different systems increases it yet further. Understanding this complexity and bringing it under control is the central challenge of our discipline.

Marc Prensky[3] writes: "I believe the single skill that will, above all others, distinguish a literate person is programming literacy, the ability to make digital technology do whatever, within the possible one wants it to do -- to bend digital technology to one's needs, purposes, and will, just as in the present we bend words and images. Some call this skill human-machine interaction; some call it procedural literacy. Others just call it programming".

3. What purpose should the teaching of ICT and Computing in school serve?

Computing is pervasive in our society, from controlling our cars (and traffic), to administering our money, to recording and transmitting information and news. In this rapidly-evolving context, those individuals and societies that are best equipped to understand, apply, modify, and develop information systems will have a significant competitive edge. Those individuals and societies that do not have computing skills will be reduced to passive users and importers of technology.

The following fundamental principle should determine the purpose of ICT and Computing in school. Schools must educate our children so that by the time they become adults they are capable of making intelligent and informed choices about the digital technology that underpins their world and they are capable of making valuable contributions to our digital society and economy. The purpose of ICT and Computing in schools is to equip every child with the basic understanding of computers and with the IT capabilities necessary to take their proper place in a digitally enabled, knowledge based society and economy.

Around one million people in the UK are estimated to be employed in a 'computing role' out of the tens of millions who access and use IT to support their job role. A 2001 study found 59% of the UK working population use IT in a professional context[4]. This figure does not include those using IT in education or for leisure. In the USA in 2005 around 80% of the general workforce (professional and none professional) were IT users[5]. Clearly, people in their daily lives do not need computer programming skills to use IT. Business people who commission new multimillion pound IT systems will probably never need to program those systems. However, there are many well known cases where overpriced and useless IT systems have been commissioned and resulted in embarrassing failure. E.g. in 2004 Sainsbury (the supermarket chain) wrote off £260m in cost associated with a flawed ICT and supply chain management system[6]. Conversely, Tesco has successfully deployed IT systems that support and enhance business

[3] [http://www.edutopia.org/literacy-computer-programming].
[4] Anni Weiler , Eurostat – Statistics on the Information Society, 2004
[5] Michael D. Steinberger, The Computer Use Premium and Worker Unobserved Skills: An Empirical Analysis, 2005
[6] Miya Knight, Computing magazine VNU Publications, Oct 2004

growth, partly due to a greater understanding of what those systems can and can't do and a deep understanding of what is required to integrate them within their business[7].

It seems rather obvious that a greater understanding of what computers can and can't do reduces the possibility of colossal and expensive IT failures and increases the possibility that IT systems will be successfully used to enhance business growth. Even an elementary understanding of programming, for example, enables the individual to become a more intelligent IT user, one far less likely to be duped into commissioning IT white elephants, one more able to make informed decisions about the value and role of technology in their life and work.

To use a food analogy, everyone should learn how to eat healthily, know about food values and be able to prepare a meal by following a simple recipe. Some become skilled home cooks or chefs and bakers, or work in the food industry, and have skills to prepare complex meals. A few will become specialists and food researchers, creating new sorts of food at the cutting edge. Many will gain great pleasure of applying what they know to enrich their own lives.

The same is true with computing. Most will have no interest in becoming technology producers. However, in order for the UK to benefit and prosper many will need to know how to use digital technology intelligently, and have an appreciation of its construction and limitations and be able to adapt it to their needs. That implies schools must provide a basic understanding of computing in addition to skills in the use of IT.

4. Is the teaching of ICT (and accompanying qualifications such as ICT GCSE) fit for purpose for all students? What should be done to address this?

Anecdotal evidence indicates that ICT teaching and syllabus is very unsatisfactory, with students bored and de-motivated. GCSE in ICT is an irrelevance in terms of its coverage, context, depth and level of challenge to a student. Alternatives such as CiDA (AiDA and DiDA), OCR Nationals, ECDL and others are equally as prescriptive and have their own limitations in addition.

One of the failures of ICT in school is the total lack of learning pathways that can be tailored to an individual's vocational and intellectual ability. There are qualifications such as Digital Creator that have attempted to ensure learning outcomes are tangible, relevant, adaptable and useful to the lives of the students at the age of study and their relative intellectual ability. That type of qualification could provide a useful framework from which multiple pathways allow individuals to fulfil their potential whether through vocational or academic routes. Unfortunately, the current regulatory system greatly hinders the ability of qualification providers in delivering qualifications that provide such flexible pathways.

Common complaints about ICT teaching and curriculum are

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[7] Alan Hughes, Michael S. Scott Morton, ICT and Productivity Growth – the Paradox Resolved? 2004

1. As each stage teaching makes the assumption of no prior knowledge, students end up being taught the same material many times – at primary, KS3, GCSE and GCE levels.
2. Many students may already know much of the material, such as the use of search engines or a word processer from their home environment or general knowledge, often better than their teacher.
3. Many students are sufficiently familiar with software and computer interaction that they are often able to find out how to employ a particular function in an application.
4. Most teachers are not specialists, without a primary qualification in computing or ICT.
5. School information and internet policies are often unnecessarily restrictive. Students are not encouraged to explore.
6. ICT (and computing) qualifications at A2 level have the reputation of being a subject that is hard to do well in, compared to mathematics, which may discourage students from the subject. This may be an artefact of the marking scheme used, and appears to have some basis as shown by the results in the chart below Figure 1.

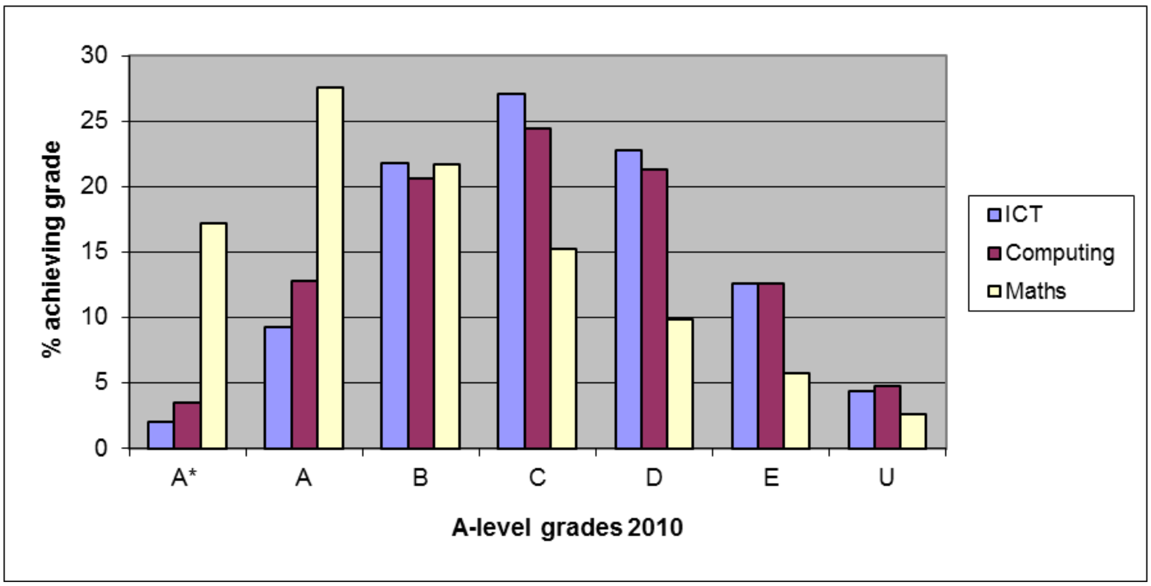


Figure 1: Chart showing comparative difficulty in gaining high grades at A2 level

7. ICT specialists and computer scientists are presented poorly in the media with implications that ICT jobs are low status, routine, badly paid, held by anti-social geeks and likely to be offshore[8] or "evil hackers". This further discourages take up.

[8] For example "The IT Crowd" Channel 4 http://www.channel4.com/programmes/the-it-crowd
"Banished from the ivory towers …. the IT crowd lurk below ground, avoiding work and social contact in equal measure..."

Solutions include:

1. A major revision to the syllabus to provide "joined up" and relevant learning from primary school through to further education.
2. Qualifications and the curriculum need to provide a wide range of learning pathways that ensure every student can fulfil their vocational and intellectual potential. Academically inclined students and vocationally motivated students must be given a range of opportunities within the same framework tailored to their ability.
3. Educate and employ domain specific teachers with primary qualifications in computing or a related field.
4. Establish centres of excellence, teacher's hubs and support networks, and a subject specific association, as in comparable subjects. The current Government has put in place mechanisms to support the revision of curriculum and assessment through the establishment of free schools, or the sponsorship of academies, which then give schools and teachers the freedom to establish new curricular ideas. Part of a wider solution would be to take advantage of such mechanisms to establish such centres of excellence and act as central 'spokes' to support and develop the hubs.
5. Provide opportunities to explore, to learn by doing. The subject has a strong constructionist heritage, such as that of Papert's *Mindstorms: Children, Computers, and Powerful Ideas*[9], but few schools provide "sandboxes", let alone encourage students to program.
6. Qualifications should be revised to reflect the updated syllabus and relevance.
7. Although some competitions such as robotics, cipher challenges and Informatics Olympiads have proved popular, motivating and attracted media coverage, they have been sporadic and patchy. Consideration could be given to a national computing challenge.
8. The BBC micro project lead the way and introduced many to computing. There may be a case for a modern equivalent or a popular TV series on the wonders of computing.

5. Is computing and ICT best 'taught' in classrooms or 'learnt' by other means? How do learners learn computing and ICT skills?

"Education for everyone" implies a considerable proportion of classroom teaching. ICT, in the sense of the use of computer tools, is universal like literacy or numeracy, and therefore should not be taught as an isolated subject beyond primary level. Computing, like English or Mathematics is a discipline and discrete subject in its own right.

[9] Seymour Papert *Mindstorms: Children, Computers, and Powerful Ideas*, Basic Books 1980, ISBN 0-465-04674-6

A comprehensive basic education in computing for all children can only be effectively delivered through regular timetabled school based lessons. It is simply not possible to put in place a national infrastructure that can deliver education to every child outside of school. Volunteers running after school clubs or other agencies attempting to provide extra-curricula activities will only reach a small percentage of school age children. Of course such activities are important and are very valuable in reinforcing what happens in schools. A classroom in this sense should of course mean a room within the school populated with computers that children can use to create exciting and interesting computational artefacts. That may mean creating games, animations, mobile-phone apps, interactive puzzle solvers, or anything else that requires analytical computational thinking to create.

As mentioned in response 4 above computing has a strong constructionist tradition, following the work of Papert and his group at MIT, of learning by doing. Some schools already use tools such as Scratch/BYOB developed by the MIT group, and others, such as the Android App creator acknowledge their debt to this work. Students should, especially in early years, be encouraged to explore the subject, and write programs, from turtle graphics to active web pages, games and apps. Unfortunately school computer systems are often too rigorously locked down to enable this. More able or lucky students may overcome this at home, or at computer clubs such as http://hackerspaces.org/

Wherever computing is taught or learnt, there needs to be consideration of how best to use the disruptive technologies that are changing the face of computing and already impacting education systems, in particular social networking. Social networking offers the prospect of working with associated social and community entrepreneurs to enrich the student experience in the classroom and outside school. A challenge that needs to be addressed is how to ensure new disruptive technologies reinforce the education environment and are continuously refreshed.

Unless a school has a teacher who is either suitably qualified or enthusiastic, pupils will learn about computing (and by this the pupils will mean programming) on their own guided by whatever online resources (tutorials, forums and the like) or books that they can find. This is no different to them than pursuing any other hobby such as film-making, electronics or baking. However, the discipline of computing is best taught in schools as there is much (as noted above) that requires specialist input and guidance that goes beyond the acquisition of a skill. Even if the latter were all that was required, the self-taught learner can gain a great deal from more structured learning.

6. What motivates learners to study computing? Is it what they learn in school or something else?

Learners are not isolated in school, but peer pressure, parental opinions, societal and media views, job and further educational prospects all play a role. A recent 2010 study by EngineeringUK shows that motivational factors vary significantly over the 13-19 age range. Whereas thirteen year olds are still very aspirational in their outlook, nineteen year olds are much more motivated by earning potential. This demonstrates that inspiring students at thirteen (and earlier) is key to ensuring they are not permanently dissuaded from studying computing later.

If lessons are dull and boring, and the subject is perceived poorly, a vicious circle can evolve, and unfortunately has been allowed to. Poor lessons demotivate learners, who generate negative attitudes, which in turn demotivates teachers, with the result of weaker teachers with less support, and so the cycle repeats.

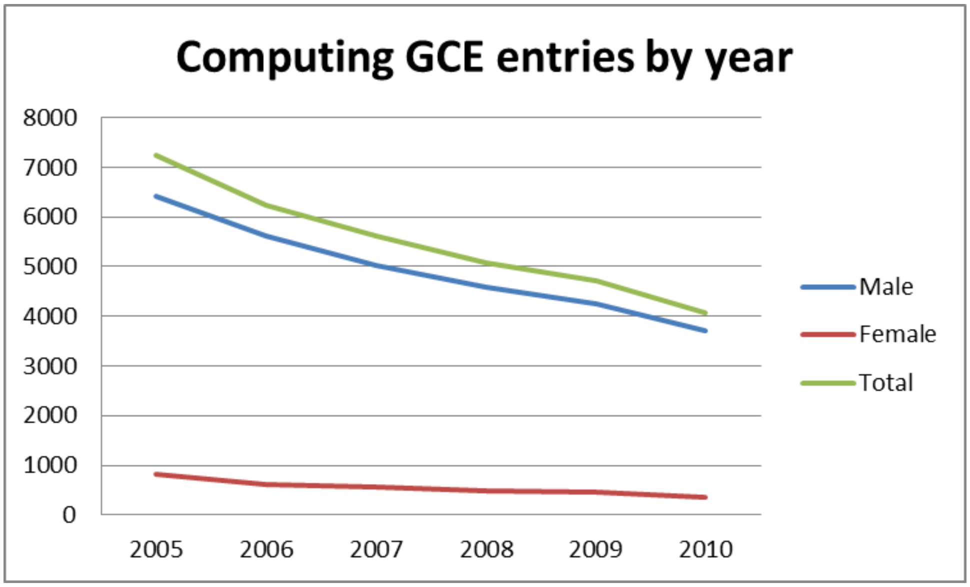
Teachers report that many who make it through to study computing at A Level are motivated by a desire to program – pure and simple. They are motivated to learn a new skill, which for them is very exciting, or to learn how to program better and are receptive to being taught better methods, algorithms, and ways of solving certain problems. Many of the most able are used to working out solutions for themselves and creating complex solutions to their own problems. They have relied on internet chat rooms and forums for guidance and advice. While this is to be commended, it does not form the foundation for the professional workforce that is expected by industry and does not engender some of soft skills desired in communication and analysis. Nor will such a small band of enthusiasts be able to fill the demand from industry for talented IT professionals.

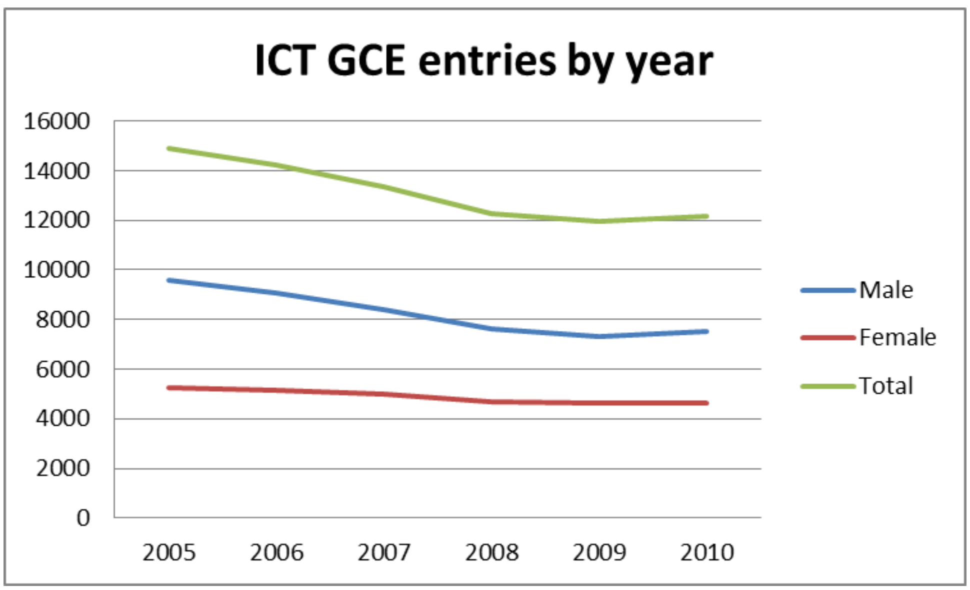
7. How is computing presented at school, and is there variation between school? Why?

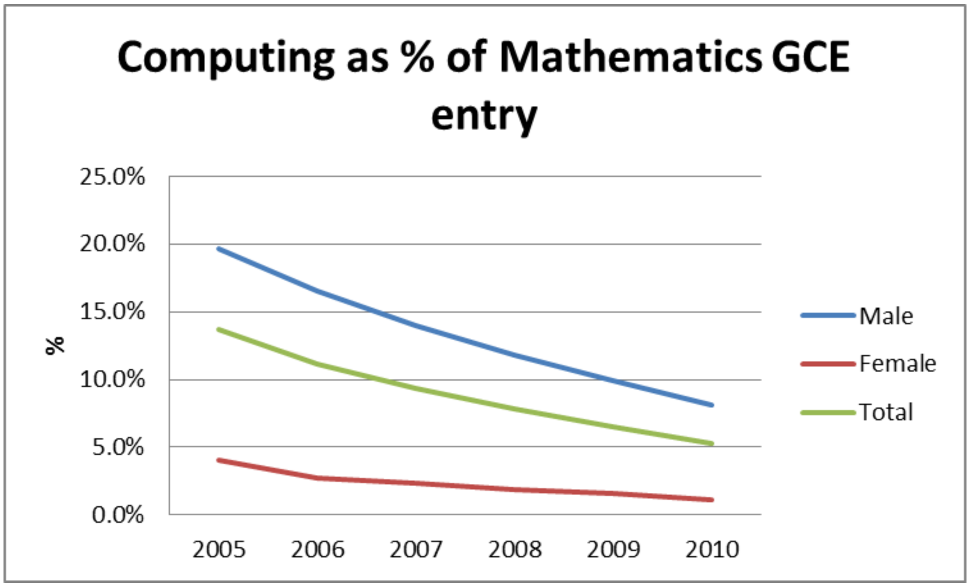
There is anecdotally a great variation between schools, between exam and qualification boards, and between individual teachers.

Few schools now offer computer science at GCE, and the takeup is low, roughly 5% of mathematics entry. There is a vicious circle: with little demand few schools offer or make timetable space, and since the subject is not offered few learners request it. There is currently a pilot Computing GCSE, but only a small fraction of schools have taken this up so far.

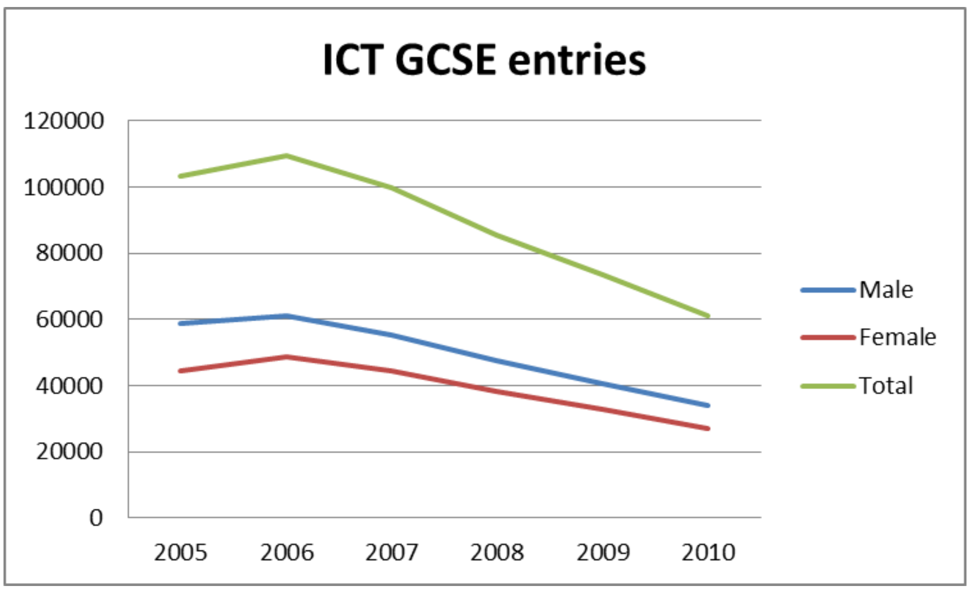
For illustration the following charts are based on the results published in June 2010 by the Joint Council for Qualifications [i]. They indicate a decline of roughly 50% over the last six years. In 2010 only about 5% took computing compared to those taking Mathematics at GCE, indicating it is a subject 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.

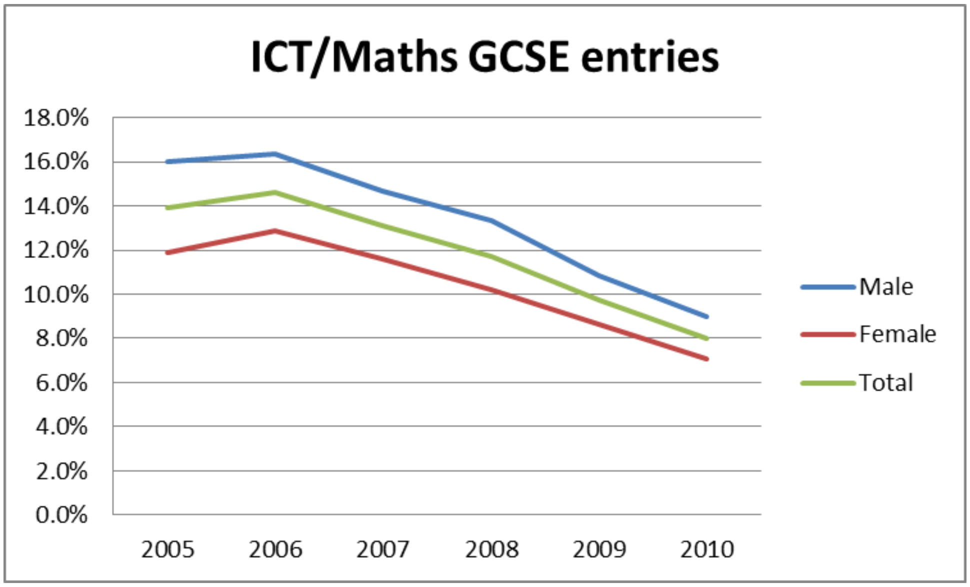

Computing GCE entries by year
8000
7000
6000
5000
4000
3000
2000
1000
0
2005
2006
2007
2008
2009
2010
Male
Female
Total


ICT GCE entries by year
16000
14000
12000
10000
8000
6000
4000
2000
0
2005
2006
2007
2008
2009
2010
Male
Female
Total



Looking at GCSE[ii] 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.





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 2 shows comparative data from Ofqual[10] 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.

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

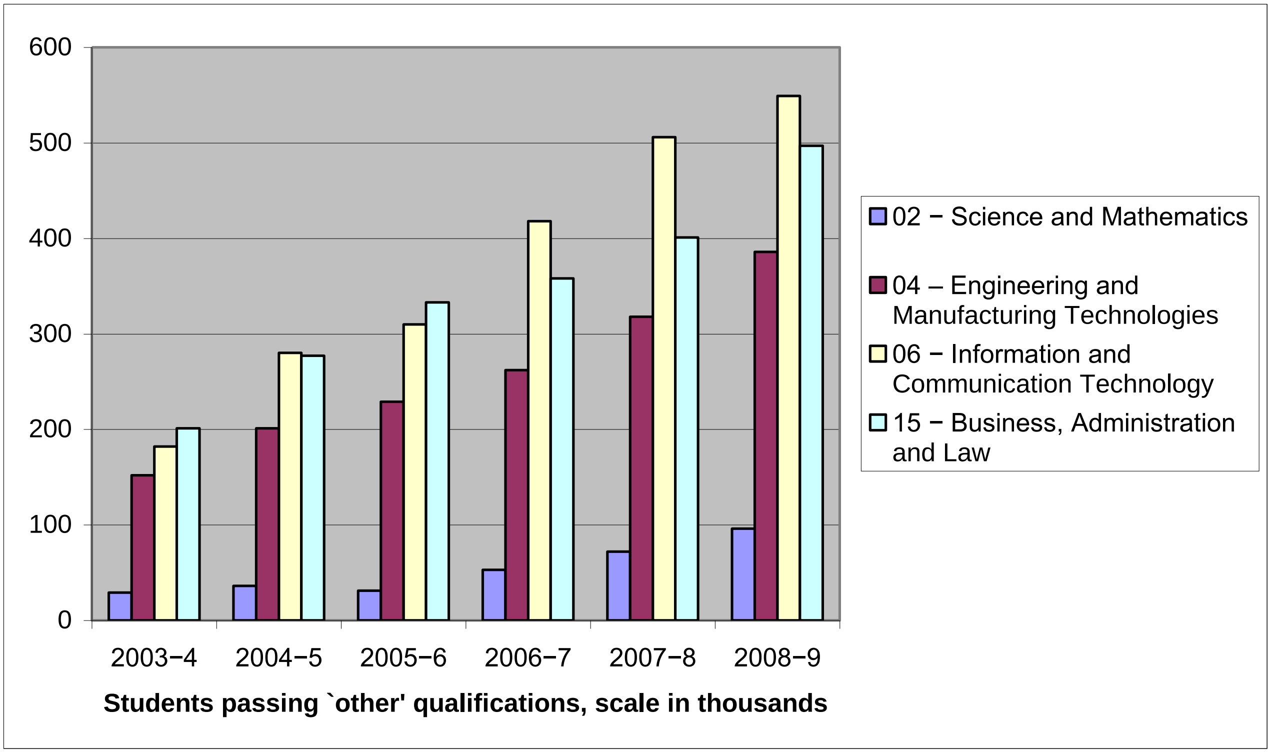


Figure 2: `Other' qualifications passed in England from Entry Level to Level 3

Figure 2 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 Computing component.

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[11] that the `principal learning' component (which should correspond to the more academic content) of Diplomas in general is not delivered 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

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

Computing and how they are put into practice is likely once again to lead to an unacceptable learning experience for students.

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.

8. Who is teaching computing, and what qualifications do they hold? Are teachers sufficiently supported with subject-specific CPD? Are there enough specialist teachers? Why do they leave/join the profession? What are the barriers to improving the situation?

According to the Department of Children Schools and Families "Secondary School Curriculum and Staffing Survey 2007" (Report DCSF-RR206) 59% of ICT teachers have no subject qualification, while only 23% have a degree in a related subject. Even that is likely to be an overestimate as the report notes: "Teachers qualified in other/combined technology were treated as qualified to teach design & technology or information & communication technology."

That is not to say that there are not able and gifted teachers without formal training in the subject, but they are the exception. Computing is a readily employable skill, with salaries and conditions in industry often superior to those in the teaching profession, so those who can leave do so.

What are the barriers to improving the situation?

The barriers are, in part, those of perception. The subject has been in slow decline since the glory days of the BBC Micro, when a vicious circle of poor education and poor results set in, even though many schools (and homes) are well equipped with computers and internet access. The decline of computing and the rise of applications based trudges through four periods per week was not the intention of anyone……it just happened as various stakeholders reacted to circumstances.

To reverse the decline a virtuous circle must be established, with computing perceived as high status, attracting able students and teachers. This cannot happen overnight, but over a period of support, with better training, curriculum change, and even media support. Perhaps it is time for the equivalent of the BBC Micro, and its associated TV program but recast for today. Some aspects of computing, such as decision mathematics are covered in some mathematics syllabus, and one suggestion is to include more computing in mathematics as pump priming and an introduction.

If teachers are to be motivated to engage with CPD in computing there needs to be recognition of their enhanced knowledge through some form of professional accreditation by professional bodies. Such recognition improves their chances of salary progression and promotion, which is a sure fire way of motivating individuals to study further. One form of recognition that some teachers have suggested is Chartered Computing Teacher status. In general professional bodies should work with the teaching profession to ensure that they are recognized through appropriate Chartered status that enhances their career prospects.

9. Why do some universities prefer their undergraduate applicants to have studied mathematics rather than computing at A-level?

1. **Scarcity**: Candidates offering Computing A-level/GCE are scarce in the student body. They therefore cannot be relied upon to give a meaningful comparative grading, and in any case much of the material will have to be re-taught in the first year, which can be demotivating for the student. At best they indicate an interest in the subject. Mathematics, with perhaps some self-taught programming, at present offers a better fit to a typical first year syllabus and indication of ability.
   To quote one University admission site[12]:
   "There is often confusion over the value of the various computer-related A-levels when applying for CS. A-level ICT, IT and Computing are more vocational in nature and are generally considered less desirable than a physical science. Newer A-level Computer Science courses are more relevant but are not universally offered and so much of the material must be repeated by us. As a general rule, we pay most attention to your mathematics qualifications"
2. **Standard**: The ICT syllabus , and the skills taught on ICT courses, as presently defined are mostly irrelevant for University computer science courses. The Computing syllabus, while better, still does not satisfy entry requirements or stretch more able students.
3. **Low scoring**: Computing, as noted in 4 above, is seen as a low scoring subject in school, and is therefore avoided by more able and ambitious students.

10. What are the perceptions of computing and ICT amongst learners, teachers and headteachers? How can information, advice and guidance be improved?

ICT and computing has a poor perception among learners, teachers and head teachers.

Learners

For many learners their first impression of the subject is via ICT, as computing is not taught lower down the school, if taught at all. ICT is seen as dull and repetitive, attempting to teach things like how to use a word processor which the better learners have known since before they could write, and often know more about than their teacher. Although some learners will have been enthused by activities such as

[12] http://www.cscubed.org/entry/

turtle drawing in primary school, their enthusiasm is soon turned off by ICT in secondary school. Computing is then seen as "just more ICT", and a subject for geeks and nerds, and even then one that does not help with university entry or job prospects. Some of the more interesting aspects, such as electronics, robotics and making things have migrated to design and technology, and creative stuff, such as audio and video mashups are covered with more immediacy in media studies, while some of the theory such as binary numbers and decision logic is taught in the mathematics syllabus.

Teachers

Most teachers do not have a primary qualification in ICT or computing. Those that do can earn more elsewhere. So except for a few dedicated and brave souls it is seen as a minority difficult subject, poorly supported. The school ICT and network resources are typically not controlled by those who teach it, and the school's IT policy is often restrictive. There are schools, for example, where files cannot be written to the filing system, nor can local private storage be used.

Head teachers

For head teachers ICT and Computing are subjects fraught with danger (evil hackers and inappropriate content), where qualified staff are difficult to find, support cost high, and where the school is unlikely to do well because of the reputation for low marking. If ICT was not compulsory in the National Curriculum many schools would not teach it.

11. Are these issues unique to the UK?

These issues appear common to the western world with Universities in EU and US reporting a similar decline in applications to read computer science. For example, in the USA the ACM and Computer Science Teachers Association recently published a new report "Running on empty: the failure to teach K-12 computer science in the digital age"[13]. However in Asia, in particular in China and India computer science education is flourishing, with 30% of all engineering graduates specialising in ICT[14].

It would be very valuable to conduct an analysis of the impact of world organisations, particularly those that seek to determine political norms (World Bank, OECD, etc.). This is a topic that would be suitable for a body such as the Royal Society to investigate further.

12. What can universities do to improve the situation?

Many university computer science departments already have active out-reach programs, of which QMUL's CS4FN is an outstanding example. Others link with local schools, or encourage graduate students to mentor local kids. More could perhaps be done with teacher training, conversion courses to

[13] http://www.acm.org/runningonempty/fullreport.pdf
[14] OECD Information Technology Outlook 2008

teaching for CS graduates and other encouragement for CS graduates to go into teaching, but there is little evidence of demand. Where Universities could contribute would be in supporting local teacher hubs, which provide teachers with self help groups and give them access to academics who are sympathetic to their cause.

Another area that should be explored is the link between FE qualifications and entry to second year undergraduate Computing courses. In some cases an FE college works closely with their local University to ensure qualifications such as HND permit direct entry to second year degree courses. Although this does not directly remedy the school issue, it does permit another pathway to higher learning and is another means of increasing the pool of potential computing school teachers.

13. Is there a case for curriculum reform? Is this the barrier?

There is a strong case for curriculum reform,

1. To provide "joined up" and relevant learning from primary school through to further education.
2. To move ICT to be an enabling subject such as literacy or numeracy, with computing as a separate discipline equivalent to maths or physics
3. To update the content in this fast moving subject
4. Establish Computing as a proper subject discipline, learned by every student at KS1,2,3, and with rich opportunities for specialisation at KS4,5

However while curriculum reform is important, it is not a magic wand or the only barrier to be overcome. Societal perception, trained teachers, accessible facilities, relevant and attainable qualifications, and position on the national curriculum all play their part.

The time when the department curriculum offer was decided by teachers has long gone. It has been driven out under the pressure of performativity and the concept of "exam yield".

Locating resistance to "computing" with ICT teachers is, in the vast majority cases, wrong. Most express deep frustration at the endless and tedious task completion and "evidence" annotating and uploading which is inherent in many of the KS4 awards.

Curriculum development is over shadowed in many places by an understandable risk aversion where innovation might lead to a small pat on the back and failure in terms of league table position. This means that schools in "well off" areas who feel less threatened would be more likely to offer a broader curriculum than those "under pressure". This, indeed, seems to be the case.

14. Is there a need for an increased recognition of ICT and computing as part of the T in STEM, through representation in STEM forums and increased funding

Very much so. For historical reasons computing has not featured as primary subject. For example computing is not mentioned at all in the STEM program report (2006)[15], with ICT only mentioned in passing. At the time of writing it appears that Government Ministers publically support the view that Computing is a key STEM subject, but that funding bodies such as HEFCE are ambiguous about giving Computing equal status with traditional STEM subjects. At the time of submission it was not clear that HEFCE will give any commitment to funding Computing in the same way as the existing STEM subjects.

15. What happens if we do nothing

Economically we will dramatically lose out to those who can develop new technology. Politically we lose control of our communications, media and data.

Figure 3 is taken from a recent EC report[16] and shows the employment and monetary value of IT producing industries to the economy. The graph shows that within the EU industries across the ICT sector (i.e. companies that create computer technology, software or computer services) added €550b in value to the economy in 2007. The software and computer services component of that was around €220b. Within the EU the number of people employed in the software and computer services sector has increased 50% from 1999 to 2007, even though the overall ICT sector has fluctuated due to the dot-com crash. Moreover, that has been a continuous year on year increase even during the dot-com crash in 2001 when some related sectors such as Telecoms took a big tumble. Without an educated and skilled workforce we put this industry in jeopardy.

This data demonstrates that just within the EU there is a massive economic opportunity to create business growth. However, that growth is only achieved through substantive R&D spend, which will not happen unless there are the right software researchers and professionals to carry out that R&D. Figure 4 is a pie-chart showing the percentage share of business R&D within the EU across the largest industrial sectors (also taken from[16]). Note this excludes State support and includes only R&D spend from the private sector.

[15] http://www.nationalstemcentre.org.uk/res/documents/page/050110114146stem_programme_report_2006.pdf
[16] JRC, The 2010 report on R&D in ICT in the European Union, EUR 24320 EN

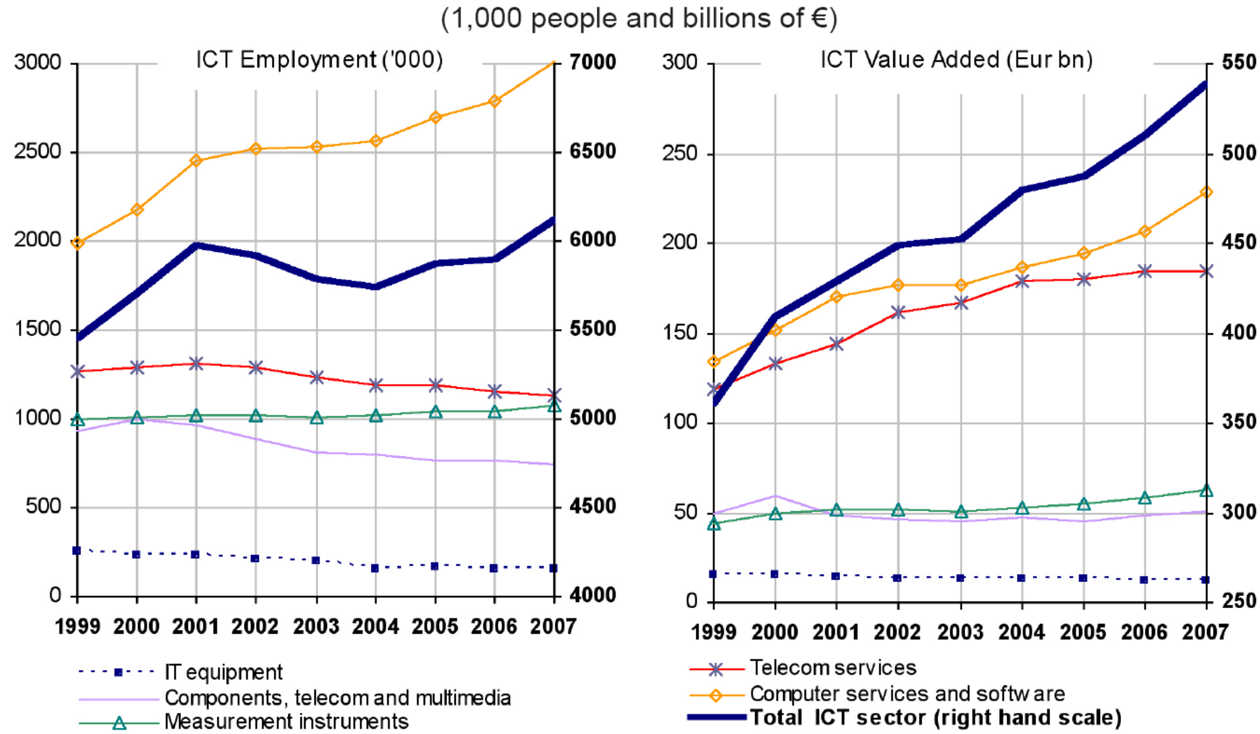


Figure 3: EU Employment and Value Added by ICT

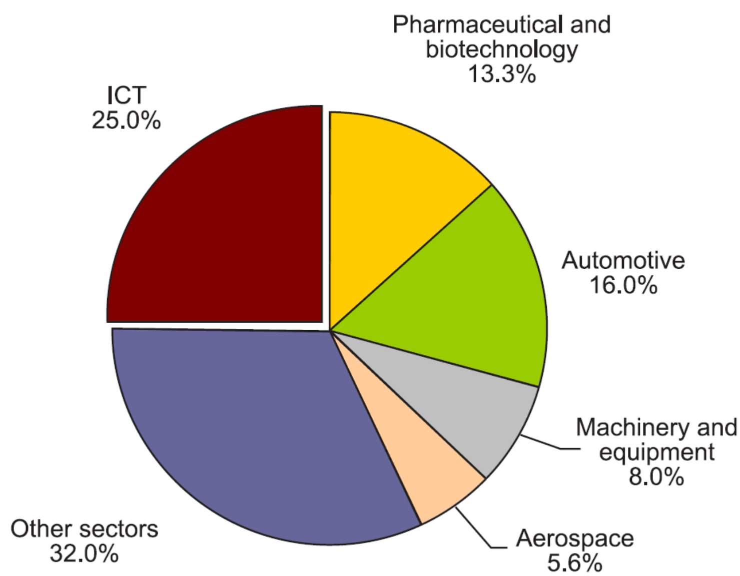


Figure 4: Business Expenditure on R&D in EU 2007

This shows that ICT has the largest share of R&D spend from business of any industrial sector. The UK still has a significant share of that but without sufficient software researchers and developers this will dwindle away to insignificant levels, which will then result in a collapse of the UK share in the €550b IT industry within the EU.

If we do nothing, we lose control of the technology that is deeply embedded in the fabric of our society. We become passive consumers without the means to innovate, control or understand. We loose our status as a developed nation.

For example without the means to critically examine and comprehend search algorithms, we have no way of knowing if search results are unbiased, news feeds uncorrupted, or databases hold and report correct information, or even if voting machines and polls are correct. Citizens would have no way of knowing or challenging the information government or others hold about them, or understand the threats from viral and other cyber attacks. The ability to use information intelligently to make informed choice is fundamental to stable democratic government, and we lose it at our peril.

16. Endnotes

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GCE results extracted from http://www.jcq.org.uk/national_results/alevels/

	2005	2006	2007	2008	2009	2010
Computing						
Male	6426	5629	5035	4588	4256	3704
Female	816	604	575	480	454	361
Total	7242	6233	5610	5068	4710	4065
ICT						
Male	9606	9052	8374	7607	7339	7543
Female	5277	5156	4986	4670	4609	4643
Total	14883	14208	13360	12277	11948	12186
Mathematics						
Male	32719	34093	36036	38719	43055	45737
Female	20178	21889	24057	25874	29420	31264
Total	52897	55982	60093	64593	72475	77001
Computing as % of Maths						
Male	19.6%	16.5%	14.0%	11.8%	9.9%	8.1%
Female	4.0%	2.8%	2.4%	1.9%	1.5%	1.2%
Total	13.7%	11.1%	9.3%	7.8%	6.5%	5.3%

ii GCSE entries sourced JCQ

GCSE	2005	2006	2007	2008	2009	2010
ICT						
Male	58713	60888	55150	47561	40629	33992
Female	44587	48713	44506	38038	32890	27100
Total	103300	109601	99656	85599	73519	61092
Mathematics						
Male	366488	371875	375877	356806	375053	378305
Female	374934	378695	384422	372645	379685	384487
Total	741422	750570	760299	729451	754738	762792
ICT % Maths						
Male	16.0%	16.4%	14.7%	13.3%	10.8%	9.0%
Female	11.9%	12.9%	11.6%	10.2%	8.7%	7.0%

Total	13.9%	14.6%	13.1%	11.7%	9.7%	8.0%