Enabling the information society

**BCS, The Chartered Institute for IT**

**in association with the Computing At School group**

**Consultation Response to:**

# Education Select Committee inquiry and call for evidence into the English Baccalaureate

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## BCS, The Chartered Institute for IT

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## Computing At School

The "Computing At School" group (CAS) is a membership association with BCS, The Chartered Institute for IT and supported by Microsoft Research, Google, Vital and other industry partners. The Computing at School Working Group (CAS) was born out of excitement with the discipline of Computing, combined with a serious concern that many students are being 'turned off' Computing by a combination of factors that have conspired to make the subject seem dull and pedestrian. Their goal is to put the excitement and intellectual rigour back into Computing at school. CAS has institutional support from Microsoft, Google, and the Council of Heads and Professors of Computer Science.

## Executive Summary

1. **Computer Science (or just Computing)** is the study of how computer systems work, how they are constructed and programmed, and the foundations of information and computation. It is a rigorous, intellectually rich discipline alongside Maths, Science, or History. Like those subjects, Computing explores principles, ideas, and techniques rather than training students in technological skills that date quickly. In an increasingly digital, knowledge-based age, Computing is fundamental both to full citizenship, and to our economic health as a nation. Section 1 gives more details.

2. **Yet, incredibly, Computing is virtually absent from UK schools.** Instead, secondary schools in England currently teach **Information and Communications Technology (ICT).** Despite good intentions, the reality in far too many schools is that ICT focuses solely upon IT literacy skills, and supporting teaching and learning in other curriculum contexts (see Section 2). ICT is not the discipline of understanding and knowledge of computers and the way they work.

3. The creation of the E-Bac provides the perfect opportunity to send a clear signal to schools and pupils of the importance of Computing. Our key recommendation is that **Computing (unlike ICT) should "count" towards the English Baccalaureate** (see Section 3). This would have two merits:

    - **Establishing a clear distinction between ICT and Computing**, and a clear "direction of travel" that Computing is to be considered a proper subject on a par with, say, Physics or History.
    - **Giving head teachers the institutional support they need to devote resources to the subject**. Head teachers are driven by league tables, and are unlikely to resource Computing if it is an optional extra that does not count as a league table measure.

4. In the body of this submission, we explain what "Computing" is and how it differs from ICT. The confusion between the two is deeply damaging, because it leads policy makers to believe that the Computing aspect of education in UK schools is adequately dealt with by ICT. In fact, it is widely acknowledged ICT has failed to fulfil that purpose in the great majority of schools; yet Computing is an area that is crucial for our nation's future.

5. We make a clear distinction between ICT and Computing by defining an exemplary Computing curriculum. A draft of "*Computing: a curriculum for schools*" is available at this URL

    http://www.computingatschool.org.uk/data/uploads/BOK_Mar_11.pdf

    It outlines a full curriculum Key Stage 3 and 4 with attainment targets, and has been drawn up in consultation with classroom teachers, business partners and academics in the field of education and Computing.

# 1 What is "Computing"?

6. To understand why Computing should be part of the E-Bac it is important to explain in what way Computing is a discipline, and distinct from ICT.

7. Computing is the study of how computer systems work, how they are constructed and programmed, and the foundations of information and computation. It is a **discipline**, like Mathematics or Physics, that explores foundational **principles and ideas** (such as algorithms for finding the shortest route through a network), rather than focusing on **artefacts** (such as particular computer programs). Its aspects of **design**, **theory** and **experimentation** are drawn from Engineering, Mathematics and Science respectively.

8. Computing includes (among many other things)

    - The study of **algorithms** and **data structures**: efficient and ingenious ways to study and solve computational problems
    - An understanding of **communication and coordination** in computer systems and networks: for example, how the internet works, and the decentralised protocols that keep data flowing smoothly.
    - An appreciation of the challenges of **human-computer interaction**, which focuses on the challenge of making computers accessible to people.
    - **The study of computation itself,** ranging from binary arithmetic and digital hardware, through to biologically-inspired computation paradigms. This reflects the richness and forward-looking nature of the subject of Computing.

    In all of these areas, there is a fruitful interaction of theory, design, and experimentation. For example, information theory informs the design of compression algorithms such as those used for MP3 digital audio files, whose performance on real test loads is measured experimentally.

9. Computing is an absolutely key discipline for the 21st century. In a world suffused by computation, every school-leaver should have a basic understanding of Computing:

    - **We want our children to understand and play an active role in the digital world that surrounds them, not to be passive consumers of an opaque technology**. A sound understanding of Computing concepts helps them get the best from the digital technology that underpins their world, and to solve problems when things go wrong. Moreover, citizens able to think in computational terms can understand and rationally argue about issues involving computation, such as software patents, identity theft, genetic engineering, electronic voting systems, and so on.
    - **Computing is of crucial economic importance**. Computer and software services contribute approximately £35bn[1] a year in GVA, and UK businesses spend approximately £70bn a year on IT products[2]. In addition, BIS figures show there are around 1.5m Computing professionals in the UK workforce[3]. For the UK to flourish we need home-grown graduates that have a deep understanding of computation, and the practical skills of design, abstraction, and programming. The lack of graduates with this background led to the 2011 NESTA report on the £2bn UK games industry, which concluded "Computer Science should be on the National Curriculum

[1] JRC, The 2010 report on R&D in ICT in the European Union, EUR 24320 EN

[2] according to 2010 European Information Technology Observatory

[3] http://www.bis.gov.uk/policies/business-sectors/electronics-and-it-services/software-and-it-services

as an essential discipline alongside Maths and Physics"4 and also "…Computer Science should be introduced in all schools and recognised, alongside art, within the new English Baccalaureate"

- **Computing develops important thinking skills, that are useful to all adults**, including logical thinking, problem solving techniques, the ability to think at multiple levels of abstraction, the habit of precision, and so on.

10. The Computing at School Working Group has developed a "Computing: a curriculum for schools", to give substance to the above brief overview, available at http://www.computingatschool.org.uk/data/uploads/BOK_Mar_11.pdf. Throughout this submission, we use "Computing" to mean the same as "Computer Science" or "Computing Science"; the latter terms are typically used at university level, but "Computing" is the term used by school teachers.

# 2 The difference between ICT and Computing

11. Computing is one of the most exciting subjects on earth. Yet the current arrangements for teaching Computing concepts at school leave many of our students feeling that it is utterly irrelevant and dull. Why is this?

12. Over the last two decades Information and Communication Technology (ICT) has been delivered as a statutory component of the National Curriculum. ICT was intended to teach students to be intelligent *users* of computational tools (i.e. software), while Computing teaches how to be an effective *author* of those tools[5]. More specifically:

- **ICT** was intended to deal with the purposeful application of computer systems, including issues such as the identification of business needs, the specification and installation of hardware and software, and the evaluation of its usability.
- **Computing** is a discipline that seeks to understand and explore the world around us, both natural and artificial, in computational terms. Computing is particularly, but by no means exclusively, concerned with the study, design, and implementation of computer systems, and the principles, ideas, and techniques underlying these designs.

13. In practice, ICT has failed to live up to its original ideal. Because of the lack of a significant Computing core in the curriculum, ICT in schools now consists largely of elementary IT functional skills. While every student should acquire these skills, we should not confuse that with the intellectual excitement and long-term personal and economic benefits of learning the discipline of Computing. We summarise some of the evidence briefly:

- The annual CBI survey shows **UK employers are dissatisfied** with basic IT skills in their workforce:
    - in 2008 - 55% dissatisfied
    - in 2009 - 57% dissatisfied
    - in 2010 - 66% dissatisfied
- The number of students taking ICT or Computing courses has collapsed over recent years:

[4] http://www.nesta.org.uk/home1/assets/features/next_gen

[5] This neat juxtaposition is only part of the truth, because it focuses too narrowly on computers as a technology, and Computing is much broader than that. As Dijkstra famously remarked, "Computing is no more about computers than astronomy is about telescopes". For example, the intellectual tools of computer science are now being fruitfully applied in Systems Biology to model and predict the behaviour of biochemical pathways in cells. In contrast ICT, as its name implies, is absolutely focused on technology, which dates rapidly.

- The number of students studying **A level Computing** fell 7% from 5,068 in 2008 to 4,710. Over the period 2001-2009, the total fell by 57% (10,913 down to 5,610)[6]. Not only is the number declining, but it is very small in absolute terms: just 0.6% of students take A level Computing.
- The number of students taking **A level ICT** reached a high of 18,029 in 2003, but has fallen every year since then, to 11,948 in 2009, a fall of 33% in six years.
- The number of students studying **GCSE in ICT** reached a high of 109,601 in 2006, but has declined particularly steeply to 73,519, a fall of 33% in only three years. (Uptake of other ICT qualifications has increased, but they are even less intellectually challenging.)

Astonishingly, although there is a host of Key Stage 4 qualifications in ICT, there were *none* in Computing, until 2010 when OCR launched a small pilot.

- The 2007 report "Developing the future"[7], sponsored by Microsoft, City University, BCS, and Intellect says *"With no GCSE in Computing or Computer Science (only the GCSE in ICT which is not about the subject of Computing) learning to use a computer and learning Computer Science become indistinguishable as far as students are concerned. The skew in emphasis has a direct bearing on a student's view of the IT industry; one that results in many negative perceptions".*
- The 2008 CRAC report "Do undergraduates want a career in IT?[8]" surveyed over 1000 undergraduate Computing students and found that *"Although the majority were happy with their choice, only 11% of Computing students felt that the discipline had been strongly promoted to them as a degree choice while at school and over 40% felt that it had received very little promotion there.... The Computing students cited a number of reasons for their choice of degree course. The overwhelming majority of male students appeared to be driven by their personal interest or aptitude for Computing (and a lower proportion, but still two thirds, of females)."*
- The 2008 "IT & Telecoms Insight Report[9]" published by Eskills UK says *"The image of IT-related degrees and careers was that they would be repetitive, boring, and more-of-the-same; for example use of IT office applications such as word processing, spreadsheets, and databases"*. The next bullet says *"The ICT GCSE had a major part to play in creating their (negative) impressions"*.
- A survey of 1000 students in July 2009 by Edge[10], an independent educational foundation, found that a majority (56%) were "unmotivated by three or more of their subjects". This result is not ICT-specific, but the same survey asked what other subjects the students would like to study instead. *The most popular choice was computer programming* (22%), beating criminology (21%) and film (18%).
- The 2009 report "ICT for the UK's future", published by the Royal Academy of Engineering states *"There is an underlying confusion between IT as a fundamental life-skill and 'enabler' in the teaching of all subjects, and Computing as a scientific discipline, with the present balance skewed towards teaching 'software use'. Students should be encouraged to explore what goes on behind the IT applications they use, from social networking and messaging tools, to computer graphics and computer games."... "It is essential that a significant proportion of the 14-19 age*

[6] Source: Joint Council for Qualifications, http://www.jcq.org.uk

[7] http://www.microsoft.com/uk/developingthefuture/default.mspx

[8] http://www.crac.org.uk/crac_new/pdfs/undergraduates_it.pdf

[9] http://www.e-skills.com/Research-and-policy/Insights-2008/2181

[10] http://www.edge.co.uk/news/gcse-students-disinterested-in-exams

*group understands Computing concepts – programming, design, problem solving, usability, communications and hardware. It is of particular importance to reform the teaching curriculum in schools to differentiate between the learning of genuine IT and the use of IT. Understanding the basis of the subject is fundamental."*

- March 2009 Ofsted report "The importance of ICT"[11] has a particularly detailed assessment of ICT. "*The assessment requirements of some vocational qualifications may actually be limiting students' achievement. In many of the schools visited, higher-attaining students were insufficiently challenged....much of the work in ICT at Key Stage 4, particularly for the higher attainers, often involved consolidating skills that students had already gained proficiency."... "Too many of the lessons seen during the survey emphasised the development of skills in using specific software at the expense of improving students' ICT capability."*
- The Royal Society is sufficiently concerned that it has launched a major study on Computing in School, due to report in late 2011.
- The 2010 NESTA report[12] on the UK games industry pulls no punches. *"Instead of building on the BBC's Computer Literacy project in the 1980s, schools turned away from programming in favour of ICT. Whilst useful…, ICT fails to inspire children to study computer programming"…"Bored by ICT, young people do not see the potential in the digital creative industries".*

14. The plain fact is that virtually no one is happy with the current state of affairs, not school teachers, not Ofsted, not employers, not pupils, not parents. The solution is to focus on the discipline of Computing, which underlies ICT.

# 3 Recommendations

15. The Select Committee's review of the E-Bac provides an ideal opportunity to provide a place for Computing in school learning. There are two main things that should be done at policy level.

16. First, **we must clearly establish the idea that Computing is a discrete discipline, distinct from ICT, and one that students should have the opportunity to learn in the same way they do Maths or Physics.** This will not happen overnight – apart from anything else there is a tremendous shortage of teachers with a background in Computing – but it would be enormously helpful to articulate the destination and the direction of travel.

17. Second, **Computing must be one of the subjects within the E-Bac portfolio**. The goals of the E-Bac are to increase the emphasis on core subject knowledge and rigour. The plain fact is that Computing is a core discipline, as important to a modern citizen as Chemistry or French.

## 3.1 The consequences of omitting Computing

18. As things stand, Computing is largely excluded from the curriculum, taught by non-specialists, and with a reputation that is low and falling because of its association with IT literacy. **If Computing is outside the E-Bac, head teachers are most unlikely to focus resources on reversing its decline**.

19. Experience shows that intellectually challenging subjects that are not mandated in some form or other have tended to become sidelined and neglected. For example, since modern languages became optional there has been a subsequent collapse in the students taking

[11] http://www.ofsted.gov.uk/content/download/9167/101177/file/The%20importance%20of%20ICT.pdf
[12] http://www.nesta.org.uk/home1/assets/features/next_gen

them at GCSE[13]: only 44% of GCSE students took a language in 2010, compared to 78% in 2001.

20. This is not just a UK phenomenon. In the US, where ICT or Computing of any sort is optional, only 40% of high schools offer any kind of Computer Science course (CSTA survey 2007[14]). Indeed, the US is so worried by the lack of Computing education in schools that Congress set up the National Computer Science week in 2010 (http://www.csedweek.org/) in an attempt to raise its profile. Conversely, in the EU where countries see a subject as of strategic national importance they tend to make it a compulsory part of the curriculum. For example, a 2004 report from the EC[15] stated that 20 out of 32 EU countries have computer programming included in their national curricula.

### 3.2 How to embody Computing in the E-Bac

21. The E-Bac currently consists of: English, Maths, a science, a humanity, and a language. We do not argue that Computing should be a compulsory component of the E-Bac, like Maths or English. Rather:

- **Computing should be one of the subjects that contribute to an E-Bac**. For example, it could be considered as "a science". Or the E-Bac could consist of "English, Maths, and three out of: Computing, a science, a humanity and a language"
- **Schools should be strongly encouraged to offer Computing**. But, because of the national shortage of teachers with appropriate qualifications, it would be unrealistic to *require* them to do so immediately. (This in turn is partly due to the stultifying nature of the ICT curriculum.)

22. The NESTA report[16] has the following intriguing suggestion**: "**This direct association of computer science with STEM can generate additional benefits: the Institute of Physics suggests, for example, that physics and engineering graduates may be shying away from a teaching career because the general science syllabus they would typically have to teach currently includes biology and chemistry – subjects they often last encountered in GCSE, but might have to teach when they join a school science department. For them, maths, physics and computer science are a much more natural fit."

## 4 Other relevant documents

- *Computing at School: the state of the nation*[17]. This report that sets out the challenge and articulates a solution.
- *The BCS/CAS response to the Royal Society Call for Evidence on Computing at School*[18]. This document gives a useful summary of the issues in question/answer format, with some graphs.
- *Running on empty: the failure to teach K-12 computer science in the digital age*[19]. This 2010 report from the USA shows that precisely the same issues are arising abroad.

[13] http://www.guardian.co.uk/education/2010/jan/20/languages-become-twilight-subjects

[14] The New Educational Imperative: Improving High School Computer Science Education Using worldwide research and professional experience to improve U. S. Schools, CSTA whitepaper 2007

[15] Eurydice report 'Key Data on Information and Communication Technology in Schools in Europe 2004 Edition', http://eacea.ec.europa.eu/eurydice/portal/page/portal/Eurydice/showPresentation?pubid=048EN

[16] http://www.nesta.org.uk/home1/assets/features/next_gen

[17] http://www.computingatschool.org.uk/files/CAS_UKCRC_report.pdf

[18] http://academy.bcs.org/upload/pdf/royal-society-response.pdf

[19] http://www.acm.org/runningonempty/fullreport.pdf