Computing at School

A national working group

http://www.computingatschool.org.uk/

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The Computing at School Working Group is an informal group that aims to promote the teaching of Computing at school. Our membership is broad, and includes teachers, examiners, parents, university faculty, local authority advisers, and employers.

CAS was born out of our excitement with our discipline, 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. Our goal is to put the excitement back into Computing at school:

- We see Computing as a rich and deep discipline in its own right, like physics or mathematics. Like those subjects, computing explores *foundational principles and ideas*, rather than training students in skills related to particular artefacts.
- Our focus is **Computing** rather than **ICT**. Computing focuses on *how computers work* and how to program them, whereas ICT is focused on *how to use computers*. Both are useful, but they are not the same, and ICT is already well served by other organisations.
- Our focus is on **UK schools**, not on universities or employers, although of course both of the latter are keenly interested in what goes on at school.
- We seek **partnership** with other organisations with overlapping objectives (such as eSkills, STEMNet, TDA, NAACE, BECTA), professional societies (such as BCS, IET), and projects (such as cs4fn, CSInside, and Greenfoot).
- We seek to work at many levels, including
  - *Directly supporting specialist ICT teachers* who are excited by computing, by providing them with teaching material, training, local hubs, and the opportunity to meet with like-minded colleagues.
  - *Launch a Computer Science Teachers Association for the UK*, modelled on the successful CSTA organisation in the USA.
  - *Working at a institutional level*, for example by encouraging the developments of GCSEs in Computing.

The challenge

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 irrelevant and dull. This is the challenge. There are a number of contributory factors, many of which are inter-linked:

- The confusion between "ICT", sometimes called "IT skills", and "Computing". Undoubtedly IT skills are important, and every student should learn them. Indeed, the campaign to get IT skills widely taught in schools has been largely successful.

  However, just as numeracy is not mathematics, ICT is not computing. Like mathematics, computing is a discipline. (We say more about what we mean by "computing" in the next section.) We should teach IT skills to every student, but we should not confuse that with GCSE and A levels in computing.

- The pre-sixth-form school curriculum is a disaster as far as computing is concerned. The emphasis for the last few years has been on ICT literacy. Whilst the original intentions were good, the attractiveness of learning ICT skills has declined as computers have become ubiquitous.

  - **Key Stage 3 (11-14):** The statutory Key Stage 3 curriculum in ICT has failed to develop imaginatively, with the cycle of updates lagging far behind where the curriculum ought to be. Most of the curriculum is heavily oriented towards IT (spreadsheets, email, internet, databases etc), and material that the students already know is often repeated. However, the recent revision to the ICT National Curriculum offers greater scope to develop introductory computing exercises, particularly in the areas of sequencing and modelling.

  - **Key Stage 4 (GCSE, 14-16):** a similar situation applies to the statutory Key Stage 4 programme of study in ICT, and the optional GCSE in ICT. The syllabi are simply boring and de-motivating. There is a GCSE in ICT, but no GCSE in Computing. By contrast, there is an IGCSE (International GCSE) in Computing but this is effectively only available to independent/private schools; state schools cannot teach it because it does not count in the school league-table scoring.

  - **14-19 Diploma**: From September 2008, the Secondary Curriculum Reform has introduced a new concept of curriculum planning, in which students are taught the core within employment sectors (lines of study). The IT and Telecommunication sector is represented by e-skills UK, which canvass IT employers' view and produced the subject criteria for the IT Diploma. Early experiences have indicated positive responses from students due to the problem solving emphasis and the opportunities for extended projects. The principal learning of the Diploma, however, revolves round Business, Technology and People. The choices available for the majority of the specialist learning options are restricted by the availability of technical courses available.

  - **Key Stage 5 (A level, 16-18):** There are AS/A Levels in ICT but these contain very little computing. Examining Boards do also offer syllabi in Computing but these have to follow a prescribed and constraining subject core shared with ICT AS/A Level, which has distorted the current AS/A Level Computing syllabi (2000-present). In 2005, however, AS/A Level Computing

was granted its own subject core for the development of revised AS/A Level Computing syllabi for teaching from September 2008[1].

- In general, A-level Computing is not considered to be sufficiently aligned with university courses in computing to be given valued status by the universities. Why not? Because the current A levels contain little of the foundational material on which a first-year university course might build. (This is being partly addressed by the AQA syllabus rewrite.) Universities do acknowledge that in a subject with a high drop out rate at undergraduate level, students with Computing A-level tend to stay the course. However, recognition by universities of A Level Computing remains a challenge. They prefer Maths. What an indictment!
- The number of students applying to computing courses at university level has halved in the last 10 years, despite increasing take-up of university education, and strong employer demand. Ironically, many at universities directly attribute this fall in numbers to the increased spread of computing at school. (The dot-com bust, ill-founded myths about outsourcing, the perceived public image of computing, and general ignorance about the shortage of well-qualified specialists in computing, may also have had an effect.) It is also worth noting here that the number of girls applying for such courses has reduced even more dramatically over the past 15 years.
- The number of students wanting to take an A level in computing is small. As a result, schools typically have at most one Computing teacher, who has no colleagues and feels isolated. It is quite difficult for teachers to keep up-to-date and quite often the students will know more than they do. This is obviously not the teacher's fault! Supporting, equipping, and training teachers are also part of the challenge.

What is "computing"?

Computing is the study of how computers and computer systems work, and 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 techniques for searching the Web), rather than **artefacts** (such as particular computer programs), although it may use the latter to illuminate the former. Its aspects of **design**, **theory** and **experimentation** are drawn from Engineering, Mathematics and Science respectively.

Computing includes (among many other things)

- The study of **algorithms** and **data structures**: efficient and ingenious ways to solve computational problems, together with a rich underlying theory of the "complexity" of such algorithms.
- An understanding of computer **systems** and **networks**: for example, how the internet works, and the protocols that keep data flowing smoothly despite all the control being decentralised.
- An appreciation of the challenges of **human-computer interaction**, which focuses on the challenge of making computers accessible to people.
- **How computers work**. Traditionally this means gates, binary arithmetic, and digital hardware. More broadly however, biologically-inspired computation paradigms are in rapid development.

[1] 14-19 Education and Skills white paper, page 65, section 8.26

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, whose performance on real test loads is measured experimentally.

Specifically, computing is not "ICT". ICT is about the **application** and **use** of computers. Computing is about their **design** and **construction**. To use the analogy of a car,

- **ICT** is the equivalent of teaching how to drive a car, how to maintain it, and how to navigate it. Once basic skills have been learned (how to use the clutch), the emphasis is on appropriate choice of destination, how to drive safely, how to develop a good route to the destination, how to choose which car is the right vehicle.

  Everyone should be able to drive, and similarly every student should possess basic ICT skills, some knowledge of how to use them, and a thoughtful appreciation of the social and ethical implications of information technology. A minority will go on to develop ICT skills to very expert levels, without ever needing to know what goes on under the bonnet.

- **Computing** is the equivalent of teaching automotive engineering: how the clutch works, how to design new cars and components, and how to repair existing ones. Computing is more than just programming, which in the car analogy would be the equivalent of metalwork.

  Not everyone needs to know how to design or maintain a car. Similarly, only a subset of students will want to study Computing, just as only a subset want to study work in the automotive or related industry.

Although computing is not just **programming**, a working knowledge of programming is necessary for a thorough grounding in computing. In an educational context, programming plays a special role: with its focus on problem solving, creativity, sequencing and logic, programming helps foster the personal, learning and problem-solving skills required in the modern school curriculum. Furthermore, it is an extremely powerful motivator: nothing motivates students like making computers dance to their tune. For this purpose "programming" clearly includes scripting and other forms of "glue" that allow us to build large systems from software components.

We use the terms "computing", "computer science", and "computing science" interchangeably.

Partnership

Although there seems to be no organisation that is focused on computing at school, the area overlaps with that covered by professional societies, national organisations, and projects. We are eager to work in partnership with these bodies. Our goals are fully compatible with theirs, and at all costs we want to avoid competition or trespassing on turf that is already well served.

Specifically

- **STEMNet**[2] focuses on Science, Technology, Engineering, and Mathematics, which does not explicitly include Computing. But the discipline of Computing fits right into the spirit of STEM, which would be a natural umbrella body for CAS.
- **eSkills**[3] is a natural partner, being a big player in this space.

[2] http://www.stemnet.org.uk/

- **Professional societies:** British Computer Society (BCS), Institution of Engineering and Technology (IET), Royal Society.
- **NAACE**[4] is *"the professional association for those concerned with advancing education through the appropriate use of information and communications technology (ICT)".*
- **The Specialist Schools and Academies Trust**[5] *"works to give practical support to the transformation of secondary education in England by building and enabling a world-class network of innovative, high-performing secondary schools in partnership with business and the wider community".*
- **BECTA**[6] is *"the government agency leading the national drive to ensure the effective and innovative use of technology throughout learning"*
- **The Training and Development Agency for Schools**[7] **(TDA)** is a key partner if we are to help the continuing professional development of teachers.

Other projects we know about include:

- **Computer Science for Fun**[8], a magazine produced at Queen Mary and Westfield College *"Welcome to the fun side of computer science! Computer Science is no more about computers than the music industry is about microphones. Explore how computer science is also about people, solving puzzles, creativity, changing the future and, most of all, having fun ..."*
- **CSinside**[9], a programme of workshops for students and teachers, run by the University of Glasgow, funded by EPSRC. Also **Computing Scotland**[10], is "a portal website, from a student's perspective, for information about computing and computing degrees and careers available in Scotland and wider". The main message is that computing is a vibrant career path.
- Leicester University Computer Science department has started a newsletter for school students and teachers called **Inspiring Computer Science Students**[11]. It has the *"aim of showing how exciting Computer Science can be, and that studying Computer Science at University involves many fascinating topics that are simply not covered at school"*. It is edited by Roy Crole,
- **CS unplugged**[12] is a *"is a collection of activities designed to teach the fundamentals of computer science without requiring a computer"*. Developed at the University of Canterbury, New Zealand. It is aimed at 5-12 year olds, but is entirely appropriate for the age range up to 18 in UK.

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[3] http://www.e-skills.com/
[4] http://www.naace.co.uk/
[5] http://www.specialistschools.org.uk/
[6] http://www.becta.org.uk/
[7] http://www.tda.gov.uk/
[8] http://www.cs4fn.org
[9] http://csi.dcs.gla.ac.uk
[10] http://computingscotland.org/home
[11] http://www.cs.le.ac.uk/admissions/BSc/iCS/iCSnewsletter2.pdf
[12] http://csunplugged.com

- The University of Southampton, with the SmallPeice (sic) Trust and Microsoft, runs a Summer School called **Supercomputing in Engineering**[13]. Simon Cox is the relevant person at Southampton.
- **British Informatics Olympiad**[14]
- The **AQA exam board**[15] has developed a new A level in computing for teaching from September 2008.

We can look for inspiration to other subjects, especially mathematics:

- University of Southampton **Cipher Challenge**[16]. Simon Humphreys remarks *"I saw some real computing going on in the team work and collaboration required for these problem-solving challenges, more than in the majority of A Level project lessons!*
- The **Millenium Mathematics Project**[17] *"aims to support maths education for pupils of all abilities from ages 5 to 19 and promote the development of mathematical skills and understanding, particularly through enrichment and extension activities beyond the school curriculum. We also engage in activities designed to improve the public understanding and awareness of mathematics."* It has a huge variety of material available to support the teaching and learning of maths at school, including several sub-programmes with their own names, such as NRICH, STIMULUS, Motivate, and others.
- **More Maths Grads**[18] is a *"three-year project funded by the Higher Education Funding Council for England to develop, trial and evaluate means of increasing the number of students studying mathematics and encouraging participation from groups of learners who have not traditionally been well represented in higher education."* There is a curriculum element: *"Part of the mission of More Maths Grads is to re-evaluate the curriculum in mathematics in higher education. Sheffield Hallam University will undertake a national study to assess what universities should cover and to increase the scope of mathematics courses to allow real choice for a wide range of students."*

We can look to other countries too

- In the USA the **Computer Science Teachers Association**[19] acts as *"a voice for K-12 computer science education"*. The ACM has also just formed an **Education Policy Committee** (EPC) whose purpose is *"to influence education policy on behalf of the computing community; the primary focus is on education and advocacy in K-12 science, engineering, and mathematics (STMEM)"*. (K-12 is age 5-17 years.)

The Computing at School Working Group

Computing at School is an informal Working Group, consisting of individuals concerned to promote the discipline of computing at school.

[13] http://www.smallpeicetrust.org.uk
[14] http://www.olympiad.org.uk/
[15] http://www.aqa.org.uk
[16] http://www.cipher.maths.soton.ac.uk/
[17] http://mmp.maths.org/
[18] http://www.moremathsgrads.org.uk/
[19] http://www.csta.acm.org

- It is an open group: anyone can join
- It has broad representation, including school teachers, university academics, members from industry, members of professional societies, and exam boards.
- It is non-partisan; CAS is not there to promote the interests of any particular group (e.g. the universities, or employers), but rather to argue for the discipline as a whole.

The CAS Working Group is active at many levels, including developing a Body of Knowledge for school-level computing; in spinning up "hubs" that bring teachers together in local groups; and in developing new material that teachers can use in the classroom, especially at Key Stage 3.

More details can be found at http://www.computingatschool.org.uk/.