Fact Sheet, why computing education is important for the UK

"We don't want the next Intel or Google to be created in China or India. We want those companies and jobs to take root in America" Barack Obama President of the United States of America, May 2011.

Key Messages

1. For the first time in human history we can **automate any intellectual process** that is based on rigorously defined principles and techniques. Understanding **how** this automation works and **why** this automation works is essential computing knowledge.
2. The UK needs school-leavers to be familiar with **rigorous computing principles** if the economy is to be competitive over the long term. Education should focus on **how** computer systems work and **why** they work, because although the technology is changing constantly, the principles that future technologies are built on do not.
3. Computing is not just for techies. Tesco.com generated £2b in 2010 because their managers know how to apply digital technology to **create business value**.
4. New **disruptive** digital business models have led to an e-commerce market in the UK of over £100bn in 2010.
5. 66% of employers were **dissatisfied** with basic IT skills according to 2010 CBI employer survey. This is because school ICT lessons make pupils passive users of specific technologies that quickly become obsolete. Pupils lack understanding of rigorous principles they will need in the workplace to apply future technologies that are not yet invented.
6. There is a **virtuous cycle** linking advances in computing with advances in science and engineering. Following are some examples that have depended on advances in computer simulation and/or embedded computing and/or computer controlled robotics (not exhaustive list):
    - Healthcare: DNA sequencing in Human Genome Project relied on computer controlled robots for automated experiments, GlaxoSmithKline use computer simulations to study physical-chemical properties of organic molecules and robots to manufacture medicines
    - CERN: The Large Hadron Collider
    - Aerospace: Airbus A380 fly by wire, BAE's Mantis autonomous aerial vehicle, NASA’s Mars Rover
    - Climate change modelling
    - Nano-technology: highly efficient solar cells, light weight electric cars
    - Real-time imaging of human brain function

Evidence

- £100-billion revenue was generated by e-Commerce in the UK in 2010[1].
- £60 billion was spent in UK on IT products and services in 2010[2] by business (distinct from e-commerce revenue figures above).
- Another 150,000 IT professionals in the UK would add £44 billion in national GVA[3].
- Firms that are IT intensive are 25-30% more likely to grow (in terms of employment) than low IT intensive companies[4].
- Enterprise resource planning software can improve the management effectiveness of multinational corporations[4] by up to 26%, when properly integrated across the enterprise by IT professionals.
- The European Commission predicts the UK will need an additional 500,000 IT professionals by 2015[5].
- The CBI annual skills survey shows the percentage of UK employers *dissatisfied* with basic IT skills in their workforce has increased year on year for the last three years, in 2008 - 55% dissatisfied, in 2010 - 66% dissatisfied.
- 75% of India's technology graduates "are unemployable by India's high-growth global industries" according to a 2010 Wall St Journal article[6]
- Across the EU employment in computers services and software (excluding the telecoms sector) has increased *every* year between 1999 and 2007, which is an increase of 50% from 2m to 3m by 2007[7].
- 70,000 computer programming jobs were offshored in the US between 1999-2003. Over the same period 115,000 more highly paid computer software engineering jobs were created in the US[8].
- The Cabinet Office estimates[9] that cyber attacks cost the UK economy £27bn per year, and this figure is growing rapidly. There is currently a shortage of technology experts who understand how to combat cyber-crime in both the UK and the US.
- 25% of all EU business R&D spend in 2007 (*excluding* State funding) was on ICT, twice as much as any other industrial sector[10].
- OECD data shows 41% of IT professional jobs across the EU15 states are in computer services.

Example, Computational Biology

This example shows why essential computing knowledge is relevant to a much wider group than just Computer Scientists. It also illustrates the remarkable speed at which new disruptive technologies arise. This illustrates why the study of particular technologies is necessarily only of short term value unlike the study of underpinning principles that evolve slowly over the long term.

The UK pharmaceutical sector is the leading UK sector for investment in R&D, investing £4.3bn in 2008, which represents over a quarter of all business R&D expenditure in the UK[11]. According to the University of Cambridge Computational Biology Institute, "*Whether operating on a large or small scale the use of mathematical and computational methods is becoming an integral part of biological research*". Computational biology is not about number crunching. It requires, for example, sophisticated computer models describing how molecules can interact,

which requires defining the principles and techniques of molecular biology in computational terms. This fundamental shift whereby computing now underpins advances in biology has happened over a remarkably short space of time.

According to Google Trends, the phrase 'computational biology' did not appear as a search term in any location from 2004 until 2009, when it first appeared. On July 31, 2011 a search on Google returned 171,000 hits for computational biology jobs in the UK (that does not mean there are 171,000 jobs being advertised, simply a measure of the websites containing the phrase 'computational biology job'). On that same date the NewScientist website had slightly more than 1000 actual job vacancies including the keywords computational biology.

That illustrates the speed at which digital technology is changing, and reinforces why teaching the principles of computing is essential. Although new technologies are appearing at an incredible rate, they are still based on computing principles that will remain relevant over the long term.

The following verbatim text is taken from an advert at GlaxoSmithKline Pharmacokinetics and Translational Biology group in Ware, Hertfordshire, UK for July 2011 (bold emphasis added to highlight computing relevant keywords):

Responsibilities

- Develop and use mathematical modelling to solve practical problems in preclinical development
- Perform and champion interdisciplinary work at the boundary of biology, physics, chemistry, pharmaceutics, numerical analysis **and computer science**.
- Use modelling as a thinking tool to generate an experimentally testable question.
- Coach and mentor staff, providing training when required and general scientific support.

Basic Qualifications

- PhD or equivalent in chemical, mechanical or biomedical engineering, biochemistry, physics, applied mathematics, **scientific computing** or related field.
- Core competency in numerical analysis and **scientific computing** focusing on optimization and differential equations (ODE,DAE,DDE, PDE, SDE), particularly using FEM and CFD approaches
- Experience in **scientific computing, software engineering and programming**; Matlab and Comsol experience a plus.
- Proven experience in applying mathematical modelling techniques in pharmaceutical industry to **integrate and interpret available data** and answer practical questions.
- Familiarity with the challenges of drug discovery and forward thinking with respect to the general application of mathematical models in pharmaceutical development.
- Expertise in drug discovery, drug delivery, physiological based modelling, systems biology, **computational biology**, data and image analysis.

This advert is interesting since it stresses the value of computing, software engineering and the interdisciplinary nature of research at the leading edge of the pharmaceutical industry.

The rise of computational biology in industrial R&D over such a short period of time is the result of revolutionary improvements in digital technology that were necessary before biological computation could be useful to the pharmaceutical industry. This revolution is still ongoing, which makes an understanding of computing principles the best hope for future scientists to be capable of applying computational thinking to their own discipline.

Clearly, a student now wanting to follow Biology as a career should have a sound understanding of computing in the same way that they need a sound grasp of mathematics. The same case could be made for other sciences, such as Chemistry or Physics.

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[1] The Connected Kingdom: How the Internet Is Transforming the U.K, http://www.connectedkingdom.co.uk/downloads/bcg-the-connected-kingdom-oct-10.pdf

[2] European Information Technology Observatory 2010 survey

[3] UK Sector Skills Council for IT, Technology Insights 2011 e-Skills UK

[4] The Economic Impact of ICT, SMART N. 2007/0020, John Van Reenen, LSE, January 2010

[5] Evaluation of the implementation of the communication of the European Commission E-Skills for the 21st Century, Tobias Hüsing Werner B. Korte, European Commission Oct 2010

[6]http://online.wsj.com/article/SB10001424052748703515504576142092863219826.html?mod=WSJ_hp_MIDDLENexttoWhatsNewsTop

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

[8] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=779005

[9] "The Cost of Cyber Crime" March 2011, OCSIA Cabinet Office and Detica.

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

[11] http://www.bis.gov.uk/assets/bispartners/foresight/docs/general-publications/10-1252-technology-and-innovation-futures.pdf