UK COMPUTING RESEARCH COMMITTEE

UKCRC Briefing Document: Youth and Public Engagement

Introduction

This document is the third of three that articulates the message that the UK Computing Research Committee wishes to communicate to different audiences. This one is aimed at youth and public engagement.

Briefly, the two key messages for these audiences are:

- Computing is a young and exciting discipline, offering intellectual challenges, improvements to the quality of life and wealth creation opportunities.
- Computational ideas now pervade every aspect of life. They are influencing the way we think, the kind of questions we ask and the kind of answers we accept.

The following two sections flesh out these two key messages.

1. The Excitement of Computing

The first general-purpose computers were built in the late 1940s[1], making the discipline of computing under 60 years old: very young compared to other sciences and branches of engineering. In that brief time they have become pervasive throughout society. It has been estimated that each UK family owns about 100 computers. Most family members will know about the computers in their desktops and laptops, but will not realise that they have several in each mobile phone, even more in their car, and others in their televisions, washing machines, cookers — in fact, just about any electronic device they own[2]. Even the chip in your credit card has 30 times the processing power and 100 times the memory of the on-board computer that took the Apollo mission to the Moon.

When people *are* aware of a computer, it is usually the hardware, i.e., the electronics that they think about. But the hardware is a general-purpose device that must be programmed to do a particular task, such as control the anti-lock braking in your car. The program, also called software, is invisible and intangible, but indispensable to the successful operation of the computer. The hardware is like a well-equipped kitchen. Just as it is the recipes that unlock the potential of the kitchen to produce a wide variety of delicious meals, so it is the software that unlocks the potential of the hardware to perform a wide variety of useful processes. Programming a computer is an exciting intellectual challenge. It is not just the challenge of mastering the capabilities of a programming language, but of thinking clearly and unambiguously about the processes to be automated. Consider the anti-lock braking. What signals are available, or required, in order that the computer can form a dynamic model of the car, it's wheels, it's brakes and their interactions? How can a bad situation be automatically detected before it gets out of control, and what actions must be performed to prevent this bad behaviour? A great deal of responsibility lies on the shoulders of the programmer. Can you guarantee that your program will always behave correctly? Lives depend on it.

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1 The Manchester University 'Baby' ran the world's first computer program on June 21st 1948.

2 Most of the computing power on the planet is based on designs licensed from the British company ARM. Ten million ARM microprocessors are shipped each day.

By embedding computers in other devices we make them smarter: able to warn of and/or prevent hazards, able to offer a higher quality of performance, and to do so using less of a scarce resource. The world needs smarter energy production and consumption, to use it more wisely. We need smarter environmental sensing to provide early warning of natural disasters and ecological deterioration. We need smarter health monitoring and regulation to ensure our well-being. We need smarter educational aids to ensure that all the world's children maximise their opportunities. Realising these dreams of a better life for all requires smart computer scientists and software engineers.

The combination of the dot com bubble of 2000 and the outsourcing of programming jobs to the developing world, convinced many people that there was little demand for computing expertise in the UK. This is not true. Demand remains high in all sectors of the UK economy, e.g., finance, entertainment, health care, education. The shortage of software engineers caused by this misconception, means that salaries are high. There are also many opportunities to start up new, hi-tech companies by recognising the previously unrealised potential of novel kinds of computer-based systems, services or devices. Most of these new companies are founded by people still in their twenties, whose fresh eyes see potential that their elders have overlooked.

2. The Pervasiveness of Computational Thinking

A remarkable intellectual revolution is happening all around us, but few people are remarking on it. Computational ideas are influencing thinking in nearly all disciplines, both in the sciences and the humanities. Computational metaphors are being used to enrich theories as diverse as genetics and the mind-body problem. Computing has enabled researchers to ask new kinds of questions and to accept new kinds of answers, for instance, questions that require the processing of huge amounts of data.

Of course, we all have computers on our desks nowadays. We all use them for email, web browsing, word processing, game playing, etc. But the computational thinking revolution goes much deeper than that; it is changing the way we think. Computational concepts provide a new language for describing hypotheses and theories. Computers provide an extension to our cognitive faculties. If you want to understand the 21st Century then you must first understand computation.

As one example among many, consider computer simulations of the climate, which are essential for first understanding and then controlling global warming. Early models of the climate were too simple to do justice to the complex interactions of the many different kinds of processes that constitute the climate. High-performance computer modelling has, for the first time, enabled researchers to do justice to this complexity and thus obtain a deeper and more accurate understanding. Climate observation, via a vast network of distributed smart sensors, including satellite-based monitoring, has provided the wealth of data needed to inform these climate models. This shear scale and complexity would be impossible for humans to handle without machine assistance. Climate modellers are now able to ask more specific questions about our environment and obtain more detailed and more accurate answers.

Computational thinking is also infiltrating hypothesis and theory formation. Consider the apparent paradox between the fast feedback humans require for some simple manipulation tasks and the fact that our perceptual systems are not capable of giving such feedback fast enough. Cognitive scientists are proposing a computational explanation of this paradox: that humans have an emulator that predicts what the feedback ought to be. The emulator can be run ahead of the actual manipulation to provide the feedback that is needed. Of course, this sometimes produces errors. The characteristics of these errors provides evidence for the existence and the form of the emulator. This emulator also provides an internal representation of our bodily functions, which can also be used, for instance, for planning and hypothetical reasoning

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