

Status Update: High School CS Internationally

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Abstract

Many countries are engaged in efforts to revamp their high school computer science curricula. This paper touches briefly on the state of affairs with high school CS in Canada, Israel, India, and New Zealand. Each country has different issues to address in implementing a concepts-rich high school computer science curriculum. The paper then reviews the recent report from the United Kingdom, *Shut Down or Restart? The Way Forward for Computing in the UK Schools*.

Introduction

The time to offer substantive Computer Science to pre-college students has come. Different countries are at different stages in creating concepts-rich high school curricula, and all come with different histories. Nevertheless, when Computer Science is understood from a 2012 perspective, these are clearly the early days of the endeavor. There are many great intentions, some nascent plans, and a few accomplishments.

Rather than attempting to catalog activities that are moving rapidly, we begin with four representative examples. Then, because of its thoroughness and timeliness, we move on to review the Royal Society's *Shut Down or Restart* report, dated January 12, 2012 [4]. That report has considerable interest not only for its careful consideration of the UK's situation and its thoughtful recommendations, but it addresses issues that overlap substantially with those of concern in many countries. The similarity or differences in responses give insight into the nature of the problems and options for solutions.

Four Representatives

This section is a four-stop world tour summarizing the state of affairs in four representative countries, Canada, Israel, India and New Zealand.

Canada

Canada and the US share much more than a long border. And because some Canadian high schools presently offer other AP courses, it can be assumed that AP CS Principles will eventually be offered, too. Canadian teachers will doubtless participate in AP CSP-related professional development.

The issue is how to prepare Canadian faculty broadly to teach concepts-rich CS classes not related to the CSP effort. At present there is no Ministry of Education training program to support teaching such courses. At the provincial level there is no CS teacher training in Ontario or British Columbia. There are some faculty with a “specialist” certification who do teach computing, of course. They are supported, for example, by annual workshops at Waterloo and Toronto.

But more attention to the issue is probably needed. As Waterloo’s Sandy Graham remarked recently in email. “[In] my personal opinion, I think that CS education should be a national concern. From my perspective, the CS Education Week that is supported by ACM and has received publicity on a national level in the US is a good initiative. I think both these initiatives are worth pursuing, and would be happy to see something like them in Canada.”

Israel

For the last dozen years Israeli high school Computer Science education has been guided by a Ministry of Education curriculum [1], prescribing the five courses of Figure 1.

<p><i>Fundamentals 1 and 2</i> (2 units): Introduces the central concepts of solving algorithmic problems and teaches how to apply them in a programming language.</p> <p><i>Software Design</i> (1 unit): Concentrates on data structures, introduces abstract data structures and discusses the design of complete systems.</p> <p><i>Second Paradigm</i> (1 unit): Introduces a second programming paradigm. Logic programming, functional programming and system-level programming are three of the current possibilities.</p> <p><i>Applications</i> (1 unit): Focuses on one particular application, emphasizing both theory and practice. Current possibilities are computer graphics, management information systems and Internet programming.</p> <p><i>Theory</i> (1 unit): Exposes students to selected topics in theoretical CS. One of the current possibilities is models of computation, mainly finite automata.</p>

Figure 1: The five courses of the Israeli high school computing curriculum.

With such a sustained commitment to teaching concepts-rich computing courses, the problems of teacher training and certification have already been addressed [2, 3].

Relative to the CS Principles/CS10K discussion, the Technion’s Orit Hazzan explained in recent email, “The Israeli HS CS curriculum aims neither to prepare the students for academic studies in CS and related fields, nor to broaden participation

in computing and computer science. Rather, it attempts to deliver the spirit of CS, as [broadly] as possible at the HS level, as a scientific discipline.”

A new committee was commissioned by the Israeli Ministry of Education to study how the existing 1998 high school CS curriculum should adapt to changes in CS over the past dozen years. Their report is imminent.

India

Having a long tradition of high quality CS education at the IITs, India is representative of nations with rapidly developing economies: They know what to do, but the resources are not yet available. Teaching CS in high school must be postponed. With IT companies needing to recruit 200,000 – 300,000 graduates per year – numbers dramatically in excess of the IIT’s capacity – the task of teaching quality CS at *college* must be resolved first. Says Mathai Joseph of MSR-India in a recent personal email, “There is an acute shortage of teachers of computing in Indian colleges, and many of those who wear this tag have actually moved from other kinds of engineering and so lack a basic background in computing.” It’s “first things first” as the demands of development create pressures that cannot be ignored.

High school students may not be left behind, however, as technology enters the mix. Joseph continues, “We cannot wait to first teach the teachers: the students cannot wait and they may well learn faster on their own. So we are providing supplementary [online] material to help teachers to understand and teach the material, but we will not prevent students from learning the same things on their own.” Technology to the rescue.

New Zealand

Beginning in February 2011, New Zealand high schools were permitted to teach computer science as a formal topic defined in a national standard [8]. As Tim Bell remarked at SIGCSE, “Despite the standards being new, and older programming standards still being available, over 1400 students in 49 schools have already registered for the new computer science standards” [6].

This milestone is a midpoint in a reinvention of the New Zealand’s ICT curriculum. Called The Digital Technologies Guidelines, the process is forward-looking, the content is concept-rich, and the effort is moving rapidly. The process is perhaps most succinctly described in an “Expert Panel Report” from 2009 laying out the plan. Notice Item 5.

1. ICT, Computing, and related technologies will be provided for in senior secondary education under the Technology Learning Area and will replace the existing technological area of ICT. This area will be called Digital Technologies.
2. As part of a comprehensive consultation process during July 2009, specific knowledge and skills under the Technology learning area will be categorised into three areas. These are proposed to be “Digital Technologies”, “Graphics

- and Design”, and “Material and Processing Technologies” and will sit alongside generic technology.
3. A Body of Knowledge for Digital Technologies is being created, outlining the specific knowledge and skills for this area. Digital Technologies is likely to contain the following five sub-categories, based on the draft Body of Knowledge: Electronics, Programming & Computer Science, Digital Information, Digital Media, Digital Infrastructure (including networking, hardware, software, systems)
 4. A set of Digital Technologies Achievement Standards will be created to assess specific knowledge and skills not covered by the generic Technology Achievement Standards or other existing achievement standards.
 5. The Level 1 Achievement Standards will be available for use from January 2011, with Levels 2 and 3 available for use in 2012 and 2013 respectively, on a timeline consistent with current Ministry and NZQA timelines for NCEA Standards Alignment. These standards will contain an appropriate number of credits, yet to be determined. Draft material will be available from July 2010.
 6. Teaching and Learning Guidelines will be created for Technology, with a well developed specific section for Digital Technologies based on the Body of Knowledge, and available to schools in draft form in late 2010.
 7. The DTEP will nominate representatives to work with the Technology Reference Group, Digital Technologies Standards Writing Group and the group responsible for developing Digital Technologies Teaching and Learning Guidelines.
 8. The DTEP will continue to exist until the end of 2009 to provide input into the process as necessary and will meet as required.

Figure 2. Outcomes from Digital Technologies Expert Panel / Ministry of Education Process [9].

United Kingdom

In January 2012, the Royal Society issued a report *Shut Down or Restart? The Way Forward for Computing in the UK Schools* [4]. Chaired by Steve Furber and supported by a luminary committee and broad participation of the stakeholders, *SDoR?* is certain to have a major impact on UK computer science education policy in secondary education.

Getting Started

The report opens with the assertion that “[t]he current delivery of Computing education in many UK schools is highly unsatisfactory.” Four principal reasons are listed for this claim: (1) The national Information and Communication Technologies (ICT) curriculum, allowing broad interpretation, too often sinks to the lowest level where non-specialists can teach it; (2) a shortage of qualified teachers to teach at higher levels, (3) a lack of professional development for computing teachers, and (4) technical difficulties with the computing infrastructure at schools.

A critical contributor to the difficulty is a cycle of confusion in which students, expecting serious computing courses, get digital literacy that teaches them material (applications) they long ago mastered, from which they conclude computer science is boring, causing little interest in the subject, presenting the universities with few students choosing a CS major, resulting in few graduates and a severe talent shortage, and no one to teach the computing courses in high schools.

Then – on page 2 – the report stops and defines terms, because as it states confusion over computing-related terms extends well beyond the misunderstandings of high school students. The whole conversation has been handicapped. The terms are given in Figure 3, and the remedy for the confusion is schematically illustrated in Figure 4. The bottom line: dump *ICT*.

Terminology used in the *SDoR?* report on computing education in the UK:

Computing – The broad subject area; roughly equivalent to what is called ICT in schools and IT in industry, as the term is generally used.

ICT – The school subject defined in the current National Curriculum.

Computer Science – The rigorous academic discipline, encompassing programming languages, data structures, algorithms, etc.

Information Technology – The use of computers, in industry, commerce, the arts and elsewhere, including aspects of IT systems architecture, human factors, project management, etc. (Note that this is narrower than the use in industry, which generally encompasses Computer Science as well.)

Digital literacy – The general ability to use computers. This term is written in lower case in the report to emphasize that it is a set of skills rather than a subject in its own right.

Figure 3: Terminological definitions establishing a common vocabulary to discuss computing education in the UK.

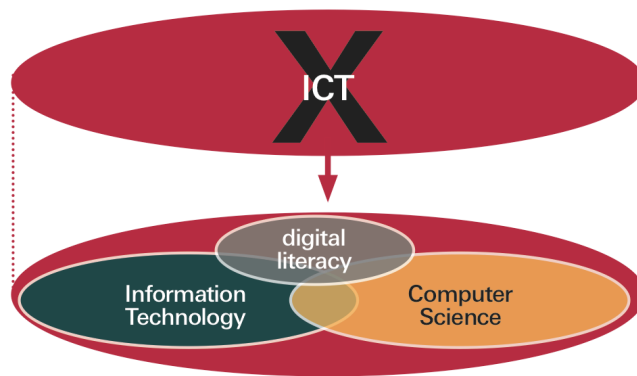


Figure 4: The proposal to focus the discussion on three terms that are meant to replace ICT in the UK national curriculum.

Observations on the Recommendations

In this section the *SDoR?* recommendations (Figure 5) are discussed relative to topics and material covered in other articles in this issue.

Word Problem

The *SDoR?* classification is very convenient, and replacing *ICT* with more specific terms is the report's first recommendation.

Interestingly, a similar terminological problem has handicapped the conversation in the US. The confusion is not with *ICT*, but with the tendency of “apps-based” literacy classes in high school – the digital literacy in Figure 3 – to be called *computer science*. These classes are so light on content that the National Collegiate Athletic Association (NCAA) stopped counting them towards sports eligibility. Indeed, the situation motivated the National Research Council to adopt the word *fluency* to describe the concept-rich class it proposed, separating it from literacy and true computer science classes [5].

Specialties versus Courses

In the US, a high school CS program following the CSTA curriculum guidelines [7] might include a sequence such as

Exploring CS > CS Principles > Java / Python Programming

In contrast, the *SDoR?* Report is classifying content, not defining courses; digital literacy is a precursor to a separate but overlapping pair of specialties, IT and CS. This seems to address a critical issue of career and technical education that has largely been absent from the CS Principles/CS10K discussions in the U.S.

Training Bursaries

Recommendation 2 describes using training bursaries as an inducement to attract college students to CS and IT teaching. The possibility of industry funding the bursaries seems like a (only slightly indirect) way of expanding the talent pool. There won't be more graduates until there are more teachers.

Shut Down or Restart? Recommendations [4]

1. The term *ICT* as a brand should be reviewed and the possibility considered of disaggregating this into clearly defined areas such as digital literacy, Information Technology and Computer Science. There is an analogy here with how English is structured at school, with reading and writing (basic literacy), English Language (how the language works) and English Literature (how it is used).
2. The government should set targets for the number of Computer Science and Information Technology specialist teachers, and monitor recruitment against these targets in order to allow all schools to deliver a rigorous curriculum. This should include providing training bursaries to attract suitably qualified graduates into teaching – for which industry funding could be sought.
3. Government departments with responsibility for Education in the UK should seek industry support to extend existing funding in this area, and should ensure that there is coordination of CPD [continuing professional development] provision for Computer Science and Information Technology teachers that deepens subject knowledge and subject-specific pedagogy.

4. School infrastructure service providers, working with others, should prepare a set of off-the-shelf strategies for balancing network security against the need to enable good teaching and learning in Computer Science and Information Technology, and should encourage schools to discuss and adopt them with their service providers.
5. *Providers of school infrastructure services should offer greater flexibility to schools to rebalance network security against requirements for effective teaching and learning in Computing. Suitable technical resources (robotics kits, etc) should also be made available.*
6. *Information, guidance and positive incentives should be offered to heads of schools to enable them to appreciate the nature and scope of Computing and how problems described in this report can be addressed.*
7. *A review of qualifications, curricula, and the means of delivering them should ensure that all pupils gain exposure to essential aspects of Computing and that those pupils with an aptitude for the subject are able to develop it to a higher level.*
8. The UK Forum (see recommendation 11) should advise Awarding Organisations on appropriate assessment methods for qualifications in digital literacy, Information Technology and Computer Science.
9. The UK Forum (see recommendation 11) should put in place a framework to support non-formal learning in Computer Science and to support teachers. Considerations include after-school clubs, school speakers and mentoring for teachers in developing their subject knowledge.
10. Awarding Organisations should consult with the UK Forum (see recommendation 11) and HE departments to develop rigorous Level 3 academic qualifications in Computer Science.
11. The Computing community should establish a lasting UK Forum for joint working and coordination between the many Computing bodies, in order to progress the recommendations within this report. The Forum should provide regular progress reports on the implementation of the recommendations.

Figure 5. Recommendations from the Shut Down or Restart? Report [4]. Italicized items are summaries of the report's official recommendations.

National Focus

A feature of many of the recommendations is an appeal to “the Government,” a phrase generally lacking in the US discussions. A significant advantage for the UK (and many other countries) is the fact that there is one voice on curriculum; in the US there are always at least fifty, thanks to its decentralized approach to education and curriculum development [see Reforming K-12 Computer Science Education ... What Will Your Story Be?, *this issue*.] Indeed, it is the fact that the Advanced Placement course content is defined at a single source, but adopted on a school-by-school basis that allows AP CS Principles to avoid the difficult task of securing fifty different adoptions.

The UK Forum

Recommendation 11 mentions establishment of a UK Forum, which the report authors envision as an organization of organizations, analogous in their view to the Royal Society of Chemistry or the Institute of Physics. Being composed of societies, it differs from the “Public/Private Partnership” mentioned in Jan Cuny’s article [see Transforming High School Computing: A Call To Action, *this issue*]. Indeed, the text mentions as advocates for reform, the Forum, universities and businesses.

Final Remarks

There is activity now in some countries to establish and/or strengthen Computer Science instruction for high school students. This is a welcome development, and it will like advance rapidly, as New Zealand illustrated, and doubtless spread well beyond the few cases cited here.

As an illustration of the challenges and opportunities in moving beyond the entrenched “literacy stage” of instruction, we have focused on the findings of a new report from the UK. In its thoughtful discussion, it highlights well the many issues involved, ranging from confusing terminology to incentivizing heads of school to make the needed changes in their institution. Not all of these will be germane (except in the UK), but all countries must deal with some combination of them. The *Shut Down or Restart?* report does show a path forward.

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