# COMPUTER SCIENCE (CS) OR INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT): CURRICULUM DECISIONS OR CURRICULUM CONCERNS?

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**ABSTRACT**

Since the 1980s, there have been concerns that computing and technologies should play a major role in school curricula and practice. Up to this present time, a major focus of technologies in the curriculum has in many countries and schools been on applications of existing technologies (both software, such as office applications, and hardware, such as robotics and sensors) into practice. Through uses of these applications, information and communications technologies (ICT) have developed practices and been involved in activities to support subject and topic learning in schools (across wide age and subject ranges). Very recently, the concern for including computers in the curriculum has shifted to a much greater focus on computing and computer science (CS), which is concerned more with the uses of and development of programming. Across the world, policy makers at national, regional and local levels are concerned about this shift: whether the shift should be made; how it can be made; and how it can be made effective for teachers and learners. This paper considers these issues largely from a school and teacher perspective, and concludes that effective policies need to consider a wider set of concerns than what might be regarded as a simple move from ICT to CS.

**KEYWORDS**

School curricula, computing, CS, ICT, national policy, economic need, future employment.

## 1. INTRODUCTION

Computers and technologies that have computing facilities now have a history in education, and their place in education is widely established. Their introduction into schools can often be traced back to the 1980s, when single computing machines, initially running programs from tape cassettes, were introduced into schools in a number of countries across the world. Since that time, computing technologies have become increasingly diverse, both in terms of the facilities they offer (for example, being able to run programs from a hard disk, being able to access resources across the world via the Internet, being able to run and play video games, or being able to locate a geographical position and find directions to another location), and size and mobility (for example, using handheld and mobile devices such as mobile telephones, laptop machines, desktop machines, or large display facilities). It is now increasingly common for individual teachers or learners to possess more than one computing device of their own (perhaps a mobile telephone, a laptop, a Moving Picture Experts Group Layer-3 (MP3) player, and a games console, for example).

The original concerns of policy makers (largely at a national level) when introducing computers into schools in the 1980s were not focused so much on how computing facilities could support subject or topic learning more widely, but were concerned much more with how teachers and learners could experience computers and computer facilities so that they might come to understand more about those that they would find in future employment situations (Passey, 2014). Although this was the key reason for computers being introduced into schools in England at that time, government agencies, research institutions and educational advisors and practitioners quickly saw opportunities and ways for computers to support subject and topic learning that would go beyond the field and subject of computing, computer science (CS) and programming.

From the 1980s onwards, software programs were developed that were designed to enhance learning opportunities in classrooms, across subject areas, for example in mathematics, language and science, and this form of development and trend concerned with subject-supporting resources has continued to this present time, to the extent that many rich resources are now accessible to teachers and learners, not only within their own local areas, but from worldwide resources.

This paper is not so much concerned with this shift in focus from early intentions to more recent intentions, but is concerned fundamentally with the current discussion about and focus for school curricula on computing, CS and programming. However, it is perhaps salient to highlight the fact that the contemporary concerns about focus on computing and CS are not new. However, it can be argued that the context in which this concern is now being discussed is different from that in the 1980s. This paper will highlight the current reasons for these discussions and concerns, it will consider arguments for a shift to computing, CS and programming, but will highlight some fundamental issues and offer some recommendations about the nature of the curriculum if it is to be effective in meeting the needs of learners and their future employment prospects.

## 2. THE PAST AND THE PRESENT

Most schools and teachers using computing technologies are concerned currently with how these facilities can be integrated into subject and topic teaching, and how their deployment can support learning. Teachers are concerned, for example, with how their learners might gain greater understanding through the teacher's uses of interactive whiteboards, or how the teacher can engage learners in reflective learning through appropriate feedback in electronic form. This focus is concerned with applications of existing computing technology facilities (both software and hardware), rather than a focus on using the underlying computing facilities themselves, and how they might be developed and used through programming or networking to solve problems. To date, the focus of many school curricula has been on: applications in subject and topic curricula; and developing uses of existing software or hardware within information and communication technologies (ICT) curricula.

Very recently, there have been discussions that have raised a fundamental issue: school curricula are not focusing adequately on computing, CS and learner uses of computing that will provide for adequate future needs. These discussions have led to some national curricula (such as those within Australia and England), now requiring a focus on computing and CS rather than on ICT (ACARA, 2013; DFE, 2013). This shift in focus and a shift towards mandatory requirements for schools and teachers to focus on computing and CS appears to be based on six main arguments, which are outlined briefly here.

There is an **economic argument**. It is argued that education should support learners in engaging through a curriculum that is most likely to support a future economy, where young people are able to meet the needs of current and future jobs and their skill requirements. Livingstone and Hope (2011), in a report on the future of the games and visual effects industries in the United Kingdom (UK), highlighted the dire need for more young people to become interested in and aware of prospects that are available to them, involving computing within this field, if these industries are to continue to develop and be fulfilled in terms of employee numbers and skills in the future.

There is an **organisational argument**. It is clear that industries and institutions are increasingly engaging and employing learning technologists to support their own individual local needs, to develop computing facilities that meet their specific organisational requirements. For example, universities and university departments are increasingly employing learning technologists, who are employed to develop and handle learning management systems to enable teachers and students to use online access and to engage in online learning that is managed and administered electronically. This trend is developing and increasing in business and industry too; and there is every reason to believe that such a trend will continue rather than wane over the next 20 years.

There is a **community argument**. That is, computing facilities are increasingly being and will increasingly be used not only by individuals for social purposes but also by 'communities', whether these are business and industry communities, or social communities, based on local government or local community groups. These forms of activities will increase the need for some individuals to be able to have and use computing and CS skills to support not only themselves but also others within their community groups for specific community purposes. Take, for example, the way that some ‘older generation groups’ are now becoming linked and engaging in uses of computing technologies to communicate with each other, and to take online courses that meet their own needs and interests (see, for example, the University of the Third Age Australia, with registration at local as well as national level) (U3A, n.d.).

There is an **educational argument**. Elements of computing continue to develop, and it is not possible to see an end-point to these developments. With new developments and new areas being opened up, there is a clear argument that education should appropriately support and fulfil these needs. The provision of a CS curriculum offers this form of provision. Additionally, it has become well recognised that CS and computing enable certain skills to be developed, and indeed that the disciplines are based upon certain fundamental skills and competencies. Skills such as problem solving, collaboration, creativity and logical thinking are often stated as outcomes for those engaging in computer science activities (Kay, 1991; McCormack and d’Inverno, 2012).

There is a **learning argument**. Current and new facilities require users to have technical, operational and application skills and competencies if they are to use and apply such facilities to support themselves and others. With computing technologies becoming increasingly ubiquitous, it can be argued that younger as well as older users should have an increasing understanding of, and capabilities to use, the full range of computing facilities that exist, whether these facilities are accessed through programming, or through application. The European Union has identified, for example, digital skills that all citizens should have, if they are to engage fully and effectively with uses of digital technologies (Ferrari, 2013). Part of these skills are concerned with computing and CS (for example, ‘apply settings, programme modification, programme applications, software, devices, to understand the principles of programming, to understand what is behind a programme’).

There is a **learner argument**. It can be argued that learners should be enabled to engage not only in what are considered to be generic areas of future need (such as numeracy and literacy), but also in areas that interest them. Computing or CS is an area that is known to engage and interest some learners (Passey, 2012), and it can be argued that for those individuals their engagement in this field should come at a time in their lives when they can potentially see ways in which that interest might shape their future as well as their immediate needs. Arguments for inclusion of computing and CS in school curricula from the age of 5 years is not uncommon (ACARA, 2013; DFE, 2013).

## 3. MAKING THE CURRICULUM EFFECTIVE

If the arguments above are accepted, then it is clear that some shift towards CS within a school curriculum is desirable. The key question is: how to do this effectively, so that schools, teachers and learners are involved in practices that support current and future needs.

The **economic argument** will require an understanding of how both CS and ICT are affecting employment and economies, and how jobs are increasingly using CS and ICT. Whether this understanding can be developed from local, regional, national and international perspectives is a question that should clearly be debated. There is some evidence that is accessible about job changes (such as that from the Bureau of Labor Statistics, 2012), but how such evidence is made accessible to schools, teachers and learners is an aspect that is likely to need some discussion and development. The United States (US) data shows employment areas that have the most likely growth up to the year 2022 (Bureau of Labor Statistics, 2012): industrial-organisational psychologists; personal care aides; home health aides; insulation workers; interpreters and translators; diagnostic medical sonographers; bricklayers and tillers; occupational therapy assistants; genetic counsellors; physical therapist assistants; physical therapist aides; skincare specialists, etc. But, whether this form of evidence can usefully be used, or accessible within a local area, or at a national level, and how this relates to computing and CS, is not at all clear.

The **organisational argument** will require an understanding of how CS and ICT are used and integrated into practices in organisations. The fact that CS skills are now increasingly used not alone, but within teams and groups (see the situation with regard to how video games are developed, for example, Passey, 2012), means that schools, teachers and learners should consider how to develop CS within team work or group situations rather than skills being developed in isolation, solely individually. In the study mentioned (Passey, 2012), where the organisation of the activities for young people in schools was based on advice from leading developers in the video game production field, teams of learners were asked to develop video game levels.

The teams worked collaboratively and co-operatively, with different skills being deployed and shared across the team. It was clear that those focusing on CS skills did not do this in isolation; they were integrally involved with the team. In these activities the entirety of soft skills deployed and developed were measured, through self-reported levels of those skills before, during and after completion of the project. Individual skill sets that were involved, and that developed further for those learners across the period of the project were: thinking skills; problem solving skills; researching skills; generating ideas; identifying solutions; making skills; evaluating skills; communicating skills; scripting skills; story boarding skills; sequencing skills; logical thinking skills; artistic skills; team working; planning skills; and leadership skills. It was clear from this project that CS skills were being used in an integrated way, and that having these skills on their own, developed in isolation, would not only provide a false view of how the industry organises team working to include those individuals who contribute CS skills, but would also not allow the skills to be easily or efficiently integrated into the entirety of the design and production of the outcome. Some studies are beginning to look at this need, in the context of learners working in classrooms in pairs, for example (Johnson, 2014).

The **community argument** will require an understanding of how CS and ICT skills can be deployed within community-based situations. There are examples of initiatives where schools, in the Netherlands, for example, enable engagement of their learners with external research issues that are identified by industry and community groups. This form of practice enables the learners to deploy problem-solving approaches, some involving levels of CS and ICT integration.

The **educational argument** will require an understanding of how CS and ICT can be integrated into curricula at school and subject levels. Many curricula are developed in ways that lead to formal classroom level practices; but it can be argued that CS and ICT require curricula that lead to non-formal and informal practices as well as formal ones. The new Australian curriculum states that learners should develop 'knowledge, understanding and skills... individually and collaboratively' (ACARA, 2013). Individual learning can be organised in formal ways, where learners have access to an individual desktop machine, perhaps. But for collaborative endeavour, it should be possible also for learners to be able to work in non-formal (groups like clubs or societies, to focus on specific interests) or informal situations (where they might use more mobile or flexible access).

The **learning argument** will require an understanding of the CS and ICT skills that should be taught and should be learned. It is easy to identify these in terms of programming; it is also essential that these skills are considered from the point of view of their context with associated soft skills. The new curriculum in Australia (ACARA, 2013) states that it:

> *aims to develop the knowledge, understanding and skills to ensure that, individually and collaboratively, students: are creative, innovative and enterprising when using traditional, contemporary and emerging technologies, and understand how technologies have developed over time; effectively and responsibly select and manipulate appropriate technologies, resources, materials, data, systems, tools and equipment when designing and creating products, services, environments and digital solutions; critique and evaluate technologies processes to identify and create solutions to a range of problems or opportunities; investigate, design, plan, manage, create, produce and evaluate technologies solutions; and engage confidently with technologies and make informed, ethical and sustainable decisions about technologies for preferred futures including personal health and wellbeing, recreation, everyday life, the world of work and enterprise, and the environment.* (ACARA, 2013: 2)

Although it does not explicitly indicate the need for learners to consider associated soft skills, it is clear that 'creating products, services, environments and digital solutions' requires a clear focus on audience, which might well (or perhaps should) involve discussion and collaboration with users so that their needs and requirements are understood and fulfilled. By contrast, the aims of the new national curriculum in England enable an interpretation at a much more individual level, meaning that associated soft skills might well be less likely to be considered:

> *to ensure that all pupils: can understand and apply the fundamental principles and concepts of computer science, including abstraction, logic, algorithms and data representation; can analyse problems in computational terms, and have repeated practical experience of writing computer programs in order to solve such problems; can evaluate and apply information technology, including new or unfamiliar*

*technologies, analytically to solve problems; and are responsible, competent, confident and creative users of information and communication technology.* (DFE, 2013)

The **learner argument** will require a balance, if the curriculum is to enable learners to develop their interests in CS- as well as ICT-based practices. Whether it is essential for all learners to have highly-developed CS skills is not at all clear. What is clear is that learners are enabled to gain what might eb regarded as 'life skills' and to take forward their interests, so that CS is provided as an opportunity for all, but that those who have particular interests are enabled to take these interests as far as they are able. The Australian Curriculum, Assessment and Reporting Authority (2013) propose to do this by mandatory integration of CS and ICT up to Year 8 (age 13 to 14 years), with learners choosing optional choices in Years 9 and 10 (age 14 to 16 years):

*The Australian Curriculum: Technologies Foundation to Year 10 is written on the assumption that all students from Foundation to Year 8 will study two subjects: Design and Technologies and Digital Technologies. At Years 9 to 10, the Australian Curriculum: Technologies is written on the assumption that school authorities will decide whether students can choose to continue in one or both subjects and/or if technologies specialisations that do not duplicate these subjects will be offered.* (ACARA, 2013: 3)

## 4. THE FUTURE AND PROJECTED NEEDS

If it is accepted that the six arguments above constitute positive reasons for curriculum change, then it is important to explore to what extent the curriculum can, and indeed already has, considered these arguments and addressed them appropriately. It might be all too easy to say that the curriculum should shift from focusing on ICT to focusing on computing and CS, but whether this might take for granted what this implies for the school, the teacher and the learner also needs to be questioned.

The economic argument implies that schools, teachers and learners will not just recognise the fact that employment will in the future involve the need for more CS skills, but should enable them to understand where those skills might be needed, and how they are used and applied within employment situations. ***Does a school have access to knowledge about the ways that CS is being used and developed in employment situations, and what future needs might arise?***

The organisational argument implies that schools, teachers and learners understand how CS skills are currently used within organisations, and what this means in terms of the organisation of lessons and activities to enable skills to be developed in a way that matches future as well as current, employment as well as school approaches. ***Does a school understand how CS and computing skills are deployed and managed in organisations, and have facilities to undertake team work or group work activities of this form?***

The community argument implies that schools, teachers and learners understand the contexts in which CS will be used and deployed. School provision is often of a formal nature; the community argument is based on a non-formal or informal, rather than a formal approach, however. ***Can a school manage and support activities that are undertaken in non-formal or informal situations, linking with community or organisations to engage with their needs through problem solving and creative solutions?***

The educational argument implies that schools, teachers and learners have access to the facilities that will enable educational outcomes to be realised. These facilities clearly concern not just computing facilities, but also the facilities that teachers can bring to the classroom, and the activities that learners will engage in. Australia is changing its curriculum, so that all pupils are taught two subjects up to Year 8 (age 13 to 14 years): Design and Technologies; and Digital Technologies. In Years 9 and 10 (age 14 to 16 years), pupils will be able to choose to take Technologies as a subject. In England, the change of curriculum to Computing requires all pupils to be taught the subject from Year 1 to Year 11 (from 5 to 16 years of age). ***Does a school have the flexibility to support a curriculum that can provide activities for all learners across certain age ranges, but offer elected courses for those beyond those age ranges?***

The learning argument implies that schools, teachers and learners are gaining skills and competencies that are of value to them in the future as well as in the present. An entire shift from ICT to CS would mean that skills and competencies that are gained from ICT might well be lost. Clearly this suggests that a balance of shift is needed, rather than a move away from one to another. ***Does a school have the facilities to enable teachers to access and use technologies to support both an ICT focus and a CS focus?***

The learner argument implies that schools, teachers and learners are concerned with a curriculum that supports engagement with practices of interest for the future as well as for the present. How learners can be supported in engaging with CS, which also balances provision for ICT, is perhaps the key question. ***Does a school enable its learners to engage at times when their interest might be stimulated in CS or computing?***

## 5. CONCLUSION

That there is discussion that school curricula now adopt CS is clear, and there are strong arguments for taking this shift forward. However, in doing so, schools, teachers and learners should not lose the vital and important components that will make this adoption successful.

Adopting CS should not exclude the need to integrate ICT across a wider school curriculum. CS should be concerned as much with group work and team work, with concerns for associated soft skills, and with audience needs, as it is with programming in isolation. CS activities should include those that consider how to integrate problem solving approaches rather than just offer didactic programming activities. ICT should consider how non-formal and informal activities can enhance learning, rather than the entire curriculum being reliant on uses in formal situations and contexts. In this way, the arguments that are made for the inclusion of a CS curriculum will be met. Fulfilling these needs may not in itself be simple, but the outcomes when successful are likely to then be fulfilling for learners and teachers alike.

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