Learning to Compute:

An Overview of Computing Education in England from 1970 to 2014

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Abstract:

This paper will present a brief history of computing education in England from 1970 to 2014. It sets out to provide the context which shaped the 2014 computing curriculum. After this curriculum had been in place for almost a decade, the paper provides an opportunity to see how computing skills, including information communications technology (ICT), have been taught in England and how that shifted towards a more computer-science-focused curriculum in 2014. This paper gives a brief overview of how the formal subjects of information technology (IT), ICT, and computing became a strategic part of UK compulsory education. It examines the introduction of computers into schools in the 1980s, what computing in schools looked like, and how different forms of computing were variously integrated into the national curriculum for England and Wales.

Keywords: computing curriculum, ICT, Digital literacy, Digital Economy, Computing education,

1. **Introduction and notes on methodology. Introducing the History, Influence and Themes of the Computing Curriculum.**

This paper sets out to provide a brief introduction to the forces that shaped the 2014 computing curriculum and to present a brief history of what computing education in England looked like prior to that point.

The paper is a narrative review of computing education literature, compiled as part of the author's doctoral studies, which builds on this and other literature to conduct qualitative research with young people about the impacts of the 2014 computing curriculum (Wohl, 2020). The purpose of this review of literature is to provide a historical accounting of the development of Computing in primary and Secondary education, providing a foundational context for past, present and future research (Baumeister and Leary, 1997). While many aspects of this history have been compiled in other papers and publications, previously, no other paper has brought together in a single narrative this development of teaching computing in the UK from its earliest beginning to when Computer Science was codified into the English national curriculum in 2014. Many of the authors cited throughout have provided key aspects of this exposition (Young, 1991; Woollard, 2018; Savage & Csizmadia; 2018; Passey, 2014, 2015, 2016; Anderson, & Levene, 2012), whereas other literature provided context, background, and a theoretical lens through which to understand these changes to how this key topic was delivered.

2. A Brief History of Computing and IT in English Schools

Formally, the teaching of computing in schools started in the 1970s with the addition of "computer studies to the GCE (A and O level) examinations for 14–18-year-olds" (Woollard, 2018, p. 14). This addition enabled pupils to approach computing as a potential career and a subject for study in higher education. The UK government began to see competing in the information economy as essential for economic success, and a skilled workforce as central to this aim. Mathematics teachers started to integrate computing technology with logical problem-solving, and teachers across the curriculum recognised the potential of computers for their subjects as well (Passey, 2014, p. 133). The potential future impact of computers was further highlighted in 1978 with the broadcast of the Horizon television programme, Now the Chips Are Down, which made dramatic predictions about how the transformative technology of computers and microchips would replace human jobs (Anderson & Levene, 2012). While too dire, these predictions highlighted the possibility that computers would powerfully drive the future economy and that individuals would need to learn the associated skill sets to remain relevant.

By the late 1970s, research machines (RM) had developed microcomputers for schools, with the Apple II and the Commodore PET released around the same time for the education market (Passey, 2014, p. 133). Due to the high cost of machines such as the RM 380Z, however, most schools could not invest in the new technology. The cost of computers fell in the late seventies and early eighties once UK companies began mass-producing them, such as Sinclair's personal computer with a QWERTY keyboard for less than £100 (Anderson & Levene, 2012; Haddon, 1991). Multiple government programs, such as the Department of Education and School (DES) and the Department of Trade and Industry (DTI), launched initiatives to fund computers and computing in schools at this time (Passey, 2014, p. 133).

By 1986, education was seen as the dominant factor in ensuring Britain's success in the worldwide information society (Lyon, 1991, p. 93). Microelectronics and computing became essential to the UK's economic success, and technology became a necessary part of both teaching and learning (Linn, 1991, p. 201). Still, a great deal of mixed messaging circulated about the 'purpose' of this new subject. While some lessons focused on problem-solving and computer programming, others focused on the use of specific applications. For example, the provision and inclusion of computing in primary schools was ad-hoc on a county basis, hampered by a lack of hardware, a lack of training and mostly a lack of adequate software to meet educational needs (Jackson et al, 1986). Jackson et al also highlight a concern that including computers in this classroom would have adverse social effects on pupils (1986). By the introduction of the UK's first national curriculum in 1989, the focus in computing had shifted to general computer usage (Woollard, 2018, p. 14). The 1989 national curriculum came in Margaret Thatcher's third term in government, from a place of deep concern with the standard of education in the UK, a desire for a higher standard across the board (Whetton, 2008). While the new curriculum did not specifically include computing, it encouraged schools and teachers to implement information technology across the curriculum. Not until the 1998 curriculum reform would every pupil learn IT (Passey, 2014, p. 134–135).

3. The 'Golden Age': Computing in Schools in the 1980s

While computing as a school subject got off to a slow start, the 1980s saw an explosion of interest and funding. Exemplary of the hype and promise early in the decade, the BBC released the BBC Micro accompanied by a series of television broadcasts called the Computer Literacy Project[1]. The idea was that children who knew how to code would have a significant advantage over those who did not, as reinforced by news stories about 'whiz kids' making a living from computer programming (Anderson & Levene, 2012). The BBC was not alone in investing resources into children's coding; other television programs broadcast in the early eighties also brought the idea of computers and programming into British living rooms

[1] The archive of this material can still be found at https://clp.bbcrewind.co.uk/ (accessed 15/4/2025)

(Anderson & Levene, 2012; Webster et al., 1991).

In the United Kingdom, on a national level, 1982 saw the launch of the conservative government's multi-million-pound campaign, 'IT82', to raise awareness of the value and power of information technology. This campaign focused on the potential of technology to transform society while encouraging the public, especially young people, to learn how to use it (Webster et al., 1991). By the mid-1980s, schools began to demand national funding to invest in equipment, technology, and training. The DTI provided significant school funding that prioritised hardware manufactured in the UK, such as the RML 380z, BBC Acorn, and the Sinclair Spectrum (Linn, 1991; Passey, 2014). By the end of the decade, DTI funding had procured computers, disk drives, mice, monitors, Teletext adaptors, telephone lines, and Turtle robots. By the early nineties, most schools had computer networks that linked them with other schools (Passey, 2014). While this was true in secondary schools, provision in primary schools was still patchy and dependent on teacher attitudes and training when it came to actual use (Hermans et al, 2008).

While the DTI was funding hardware, the DES and the Department of Employment were funding the Microelectronics in Education Programme and the Technical and Vocational Education Initiative, respectively, to train teachers and prepare young people for a future society where computers were commonplace (Linn, 1991; Passey, 2014). As a result of additional resources such as educational videos and teaching materials produced by the BBC as part of 'Micros in Schools', the BBC Micro became the computer of choice for many schools (Anderson & Levene, 2012). But computers were available mainly in computer labs, and non-IT subject teachers found they had limited access to technology-based resources in the classroom such that, 'from 1989, the idea of IT "across the curriculum" was felt […] to be worthwhile, but practically difficult to achieve' (Passey, 2014).

With the approaching publication of the national curriculum in 1989, the emphasis on IT shifted to the enrichment of the entire curriculum with topic-based resources and software (Passey, 2014). The arrival of the Microsoft Windows operating system made multimedia tools accessible for schools and young people, producing an uptick in the authoring of multimedia technologies as a core part of IT (Woollard, 2018). At the launch of the national curriculum, the pressure to use computing and IT across subjects became explicit with the stated aim that every pupil uses IT to enhance learning in every subject (Passey, 2014) and specifications for what this should look like (Woollard, 2018). A large amount of money and excitement rapidly increased the opportunities for pupils in the 1980s to learn about and with computers. Much of the early focus in the 1980s was on learning computer-specific skills such as logic and programming. By the end of the decade, 'IT82' was all but forgotten, and the focus shifted to using computers rather than learning how they worked or how to program them (Passey, 2016).

4. English National Curricula in 1989, 1998, and 2004

1989 was a watershed moment in which the first national curriculum significantly changed the education system across the country, specifying 'subject content […] for all sectors of compulsory education [with a statutory] learner entitlement curriculum' for the first time (Passey, 2014). To a greater or lesser extent, technology use was integrated into every subject area at every age level, although the primary focus remained 'design technology' (Passey, 2014). Despite not having its own curricular area, IT received five strands of progression called 'IT capability to be used for assessment': developing ideas and communicating information, handling information, modelling, measurement and control, application and effects (Barnes & Kennewell, 2018; Passey, 2014). This version of the national curriculum lasted for a decade, seeming to stabilise, formalise, and institutionalise how IT was used in schools to the point of stagnation.

With the change of government in 1997, ministers began to discuss the use of IT for broader concerns about learning, attainment, and effectiveness to raise standards across all subject areas (Passey, 2014). The 1997 Stevenson report raised concerns regarding basic IT confidence and competence among both teachers and pupils, as well as the need for a stable policy on computing learning (Woollard, 2018). This report came alongside a growing debate regarding New Labour's approach to education more generally (Whetton, 2008). Stevenson's concerns laid the groundwork for the 1999 curriculum reform, which revisited IT to create the discrete subject of information communications technology (ICT). This new subject had its own five components that defined 'ICT capability':

- Routines such as using a mouse or double-clicking on an application.
- Techniques such as adjusting margins to make text fit a page.
- Key concepts such as menu, file, database, spreadsheet, website, and hypertext link.
- Processes such as developing a presentation, seeking information, and organising, analysing and presenting the results of a survey.
- Higher-order skills and knowledge, such as recognising when the use of ICT might be appropriate, planning how to approach a problem, making and testing hypotheses, monitoring progress in a task, evaluating the result, and reflecting on the effect of using ICT in a particular situation. (Barnes & Kennewell, 2018)

These five capabilities moved the curriculum away from programming toward applying ICT to specific, often work-related tasks. Computers have moved from being 'new technology' for exploration and investigation to essential tools for any future career a child might imagine. While many concepts associated with computer science do appear among the five components, they bunch into the final capability of choosing the right tool for the right task rather than making one's own tools (Woollard, 2018).

By creating a discrete subject area for ICT, the 1999 curriculum made time for the teaching and learning of ICT but also took emphasis away from its use across the curriculum. By 2002, the focus once again came to computer suites in primary schools and specialist teaching in secondary schools (Woollard, 2018). At this time, the greatest challenge to computing across the curriculum was teachers' reluctance to use emerging technology to the point that IT skills were only taught and utilised in IT lessons. By 2004, the secondary school strategy brought about the 're-emergence of the ICT across the curriculum' (Woollard, 2018). While there was relative stability in IT provisions after the initial national curriculum from 1989 to 1997, it raised questions on computers in schools, such as what should be taught (programming, IT, ICT); why should it be taught (for industry, for work, for any other reason); and should it be discrete and or cross-curricular?

5. Where Did the 2014 Computing Curriculum Originate?

When examining the context for the 2014 computing curriculum, it's worth reflecting on Young's observation from 1991 that discussions of technology in education are polarised between specialists with knowledge of electronics and computing and 'the rest who have little concrete knowledge of either (or any other) technologies' (Young, 1991). Throughout the process of curriculum development, this tension was apparent. A range of experts advised on the changes with often contradictory recommendations that were then implemented by nonexperts (Williamson, 2015). There was at least consensus that the subject of computer science should be (re)introduced into the compulsory curriculum in the 2014 version (Passey, 2016). Computer science was a relatively new addition to post-compulsory education, with the first computer science departments arising in universities in the early 1960s and the first doctor of computer science awarded in 1965 (Passey, 2016). This is worth noting for two reasons: first, the knowledge that constitutes computer science is not fixed nor clear to the general population the way a subject such as mathematics might be and second, university student applications for computer science courses had begun to decline prior to 2014 (Peyton-Jones, 2009).

By this point, the pre-sixth-form compulsory curriculum in England emphasised ICT literacy for a small number of computer applications (Peyton-Jones, 2009). The more universal the computer became, the more ‘the attractiveness of learning ICT had seemed to decrease’ (Peyton-Jones, 2009). Much of the intended revisions to the computing curriculum reinvented the topic so it could appeal to a broader range of students; computing could apply to every aspect of life and almost any school subject (Peyton-Jones, 2009). To raise awareness for the new computing curriculum, the UK government established the ‘Year of Code’ campaign in 2014, linking the ability to write computer programs to potential economic success (Williamson, 2015), an effort that paralleled the aforementioned IT82 initiative.

6. CAS, Restart, and NexGen: Voices Shouting for Change

Several factors influenced the 2014 computing curriculum, including grassroots efforts and two independent reports, with the final catalyst for change being a speech by a global industrialist. In 2008, a group of academics, industrialists and teachers came together to form Computing Next Generation (CNG), an organisation that later evolved into the group Computing at School (CAS) (Woollard, 2018). CAS started as a newsletter and, over time, brought together a range of individuals frustrated by the lack of computer science in the national curriculum (Davies, 2017). CAS membership comprised: enthusiastic teachers with the freedom to include some aspects of computer science in their lessons; academics concerned with the drop in applications to study computer science programs at UK universities; and industry representatives from large technology companies concerned by the lack of higher-level computer science knowledge across the population (BCS, 2010; Peyton-Jones, 2009; Sentence & Csizmadia, 2015; Williamson, 2015; Woollard, 2018). CAS received funding from the British Computing Society (BCS), also known as the Charter Institute for IT, and by 2010, started to publish white papers (BCS, 2010; CAS, 2010; CAS Working Group, 2012; Peyton-Jones, 2009), including a proposed rethink of how to teach computing in UK schools (Williamson, 2015).

In early white papers, CAS distinguished ICT as a set of skills from computer science as a discipline. CAS was critical of the focus on ICT, making the case that while ICT was important, it was equally important that every child be introduced to computer science, even if not every child would make use of the concepts which comprise it (Peyton-Jones, 2009). CAS's official position was that pupils were no longer learning enough computing because the 'exclusive emphasis on ICT means that today's school pupils have fewer opportunities to learn Computing than they did 20 years ago' (Peyton-Jones, 2009). CAS drew a connection between decreasing computing enrolments and problems with recruitment for computing careers. They blamed this change on the key stage 3 curriculum, which was associated with learning how to use 'office-type' software but lacked opportunities for creativity (for example, through programming) and learning how computers work (Woollard, 2018). This could also be connected with ICT becoming a discrete subject, removing the opportunity for creativity and integration across the curriculum. Another challenge may have been the lack of

ICT/computer specialists teaching in secondary schools.

While CAS was advocating for a more comprehensive approach to computer science in schools, two public reports reviewed the state of ICT in schools. The ‘Next Gen’ report, published by Nesta and written by Livingston and Hope, looked at the connection between the computing skills young people learned in school and the digital and creative economy more broadly (2011). Specifically, Livingston and Hope examined whether young people were learning the skills and concepts they needed to enter the UK video game and visual effects industries (2011). This report advocated for young people to gain a rigorous knowledge of computers and code and advanced computer science as central to the national curriculum (Livingston & Hope, 2011; Williamson, 2015). The authors also argued the importance of linking computing with the arts in UK schools (Livingston & Hope, 2011).

In 2012, the Royal Society, the UK’s independent scientific academy, released a report calling for the reintroduction of computer science to UK schools, harkening back to when the BBC Micro introduced a generation to programming (Royal Society, 2012; Williamson, 2015; Woollard, 2018). Entitled ‘Shut Down or Restart? The Way Forward for Computing in UK Schools,’ the report was written by Steve Furber, a member of the team which initially developed the BBC Micro (Anderson & Levene, 2012; Royal Society, 2012) and commissioned by Microsoft, Google, and many university computer science departments (Williamson, 2015). ‘Shut Down or Restart’ criticised the state of ICT in UK schools, stating, ‘current delivery of Computing in UK schools is highly unsatisfactory’ primarily because:

1.1. The current national curriculum in ICT may be broadly interpreted and reduced to the lowest level when non-specialist teachers deliver it.
1.2. There is a shortage of teachers who can teach beyond basic digital literacy.

1.3.There is a lack of continuing professional development for teachers of computing and

1.4 Features of school infrastructure inhibit effective teaching of computing.

(Royal Society, 2012)

While the ‘Next Gen’ and the ‘Shut Down or Restart?” reports as well as CAS’s ongoing work were instrumental to the revision of the computing curriculum, the catalyst is generally considered to be Eric Schmidt, then head of Google, in his 2011 MacTaggart lecture (Woollard, 2018). The speech mobilised political support for computing reform, highlighting some of the same conclusions as the two public reports (Williamson, 2015). Schmidt (2011) used this platform to express dismay at the state of computer science in UK schools, stating it was hard for Google to find the talent they needed in the country (Cave & Rowell, 2014; Williamson, 2015). Schmidt (2011) metaphorically threw down a gauntlet for the UK government by stating, ‘Your IT curriculum focuses on teaching how to use software but gives no insight into how it’s made’. Just as the Next Gen report had called for integrating computer science with the arts (Livingston & Hope, 2011), Schmidt (2011) challenged the UK to ‘bring art and science back together’.

These comments prompted politicians to rebuke the teaching of ICT and call for more computer science (Williamson, 2015). Michael Gove (2012), then minister for education, gave a speech at the BETT exhibition in 2012 in which he called ICT “harmful, boring and/or irrelevant” and promised to reform the teaching of computing in UK schools with a rigorous approach to computer science in the new national curriculum. With input from Nesta, BCS, Google, Microsoft, CAS, and Raspberry Pi (Williamson, 2015), Gove (2012) made it clear that the goal of the new computing curriculum was to move away from ICT and towards computer science.

While various forces made computer science more appealing than ICT to schools and young people, most (except Michael Gove's) called not for the replacement of skills taught in ICT but rather a supplementation with computer science. Akin to Young's (1991) observation on specialists and non-specialists influencing the use of technology in schools, specialists in this case called for a curriculum that included computer science but also drew on digital literacy, ICT skills, and the arts. More importantly, the "Shut Down or Restart?" report stated, "Computer Science is sufficiently […] foundational that it should be recognised as a high-status subject in schools, like mathematics, physics or history" (Royal Society, 2012). Taking this statement seriously would have meant giving the subject of computing a much larger portion of a child's school day. Instead, while the content changed, the amount of time devoted to computing at most secondary schools remained constant: approximately one hour per week (Kemp & Berry, 2019).

7. Why So Much Computer Science?

A range of arguments have been made for why the ICT curriculum is no longer fit for purpose. On the one hand, CAS had argued that ICT provisions, while serving some students well, hampered more able students (Peyton-Jones, 2009). On the other hand, a move towards computer science moves from a skill to a discipline which prepares "young people for jobs that don't yet exist, requiring technologies that have not yet been invented, to solve problems of which we are not yet aware" (Peyton-Jones, 2009). However, both arguments pertain to the most academically able students. Both fail to ask: What about students who need to do jobs that already exist? Or use technology that has already been invented? Or solve problems we as a society are already all too aware of?

University lecturers often report that students find computer science a hard subject (Passey, 2015; Passey, 2016). Considering that computing, the ‘harder’ subject, was required to fit within the same timetable as ICT, it seems self-evident that many pupils would find it more challenging to make progress. Moreover, many ICT skills remain important for pupils’ futures, and a complete shift from ICT to computer science might mean ICT competencies would be lost. Rather, some sort of balance was necessary instead of a wholesale pivot (Passey, 2015). But the question remained whether schools had the facilities to grant teachers access to technologies supporting both ICT and computer science (Passey, 2015).

The argument of “not one nor the other but both” closely mirrors the conclusions of the “Shut Down or Restart?” report from the Royal Society (2012). The wording of these findings is key: computer science is *as* important *as* any other science; every child should be ‘digitally literate’, and digital literacy is as important as reading and writing; children should have the opportunity to learn the concept and principle of computing; and there should be opportunities to take these topics forward in a range of ways. From the phrasing alone, it seemed the two most important aspects would be to devote more time to computing lessons and to ensure every child was digitally literate by providing ample opportunities in which pupils could choose to engage or not.

8. The Case for a New Curriculum.

A CAS white paper from 2009 made the case that, in fact, much could have been achieved with the ‘admirably non-prescriptive’ KS3 curriculum in terms of computing, such as ‘planning, testing and modifying a sequence of instructions, recognising where a group of instructions needs repeating and automating frequently used processes by constructing efficient procedures that are fit for purpose’ (Peyton-Jones, 2009). If so, then the circumstance for change was not a new curriculum but rather a new approach to the existing curriculum. In contrast, Williamson contends the new curriculum meant to embed a new way of thinking about the world; in fact, computational thinking and thinking through code would change how young people thought about the world and the phenomena they encountered that might be described in code and understood as computable (2015). Williamson believed it would benefit large technology companies and government systems if pupils understood the world through computers. An overarching question, then, was whether a new curriculum would solve the problems seen as inherent to the ICT curriculum that were depressing the numbers of computer science majors and professionals (Woollard, 2018).

9. 'Computing': 'I Don't Think That Word Means What You Think It Means'

The shift from ICT to computing moved away from skills and towards disciplinary principles and ideas, ways of understanding problems and describing the world (Peyton-Jones, 2009). Disciplinary language allowed CAS to argue that computing takes its rightful place alongside mathematics and the other sciences (Peyton-Jones, 2016). No longer would students learn only how to use office-type software; they would also learn a discipline which would prepare them to understand the world they lived in better. The move towards computing reflected an international change where several countries introduced elements of computing into schools as either formal or informal learning opportunities (Savage & Csizmadia, 2015).

The idea behind the focus on computing was that it would create a more 'exciting' subject than ICT. Seeding language for Michael Gove's speech two years later, CAS went so far as to state: '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' (CAS, 2010). Given this mixed reception, what exactly made up ‘computing’? It focused on theory rather than practice—concepts rather than artefacts (CAS, 2010)—based on the following four points:

- 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. (CAS, 2010; Peyton-Jones, 2009)

Interestingly, these points do not include using specific software or learning programming or coding. What can be concluded is that the discipline of computing focused on a theoretical understanding of the digital world and was expected to be more exciting than learning how to use software. Ultimately, the purpose of computing as opposed to computer science is to provide students with skills and knowledge that can be applied to solutions across STEM subjects (BCS, 2010). Therefore, computing is cross-curricular by nature, but it is also theoretically specific and applicable to any number of other disciplines.

10. Are They Ready for the… Digital Economy?

Even in earlier debates about IT/ICT and computing in schools, the digital economy played a central role. In the 1980s, much of the argument for increasing the role of IT in schools was tied to the rise in technical vocations and predictions that microelectronics technology would transform almost every industry. It seemed essential that pupils became computer literate in school (Mackay, 1991; Webster & Robins, 1991). The IT82 campaign claimed IT would transform every sector of the economy, from factory work to public houses, management to healthcare (Webster & Robins, 1991). In hindsight, these predictions are surprisingly prescient: almost every sector has been transformed by some form of technology, an excellent economic argument for teaching relevant computing education in schools. However, relevance does not answer the question of what should be taught.

The Royal Society (2012) report, while making the case for digital literacy, underscored the danger that the lack of enthusiasm associated with the ICT curriculum could have detrimental effects on UK's education system and the ability of the UK to compete on the international stage (2012). The report makes a link between learning to code and entrepreneurial success, highlighting that "the two most successful start-ups in Computing and [the] business world—Facebook and Google—were led by people who had been writing software at university" (Royal Society, 2012). The growth in IT industries of roles in software engineering prompted commentators to glamorise the discipline of computing to recruit skilled workers for the digital sector (Williamson, 2015).

Livingston and Hope (2011) conjectured that the digital economy would not be based on a small set of technical skills but on multidisciplinary skills such as teamwork, communication, and artistic ability. They found that pupils had little sense of what it would be like to work in the digital economy, even in a relatively appealing sector such as the video game industry (Livingston & Hope, 2011). So, while the computing curriculum needed to give young people the skills to participate in this sector, they also needed to gain a sense of what careers in this sector might entail. Even with curriculum reform underway, there was still concern many young people were missing out on the opportunities available to them in the ever-expanding digital work. The Labour party commissioned a report, ‘Digital Skills for Tomorrow’s World’, to determine what skills would be needed for the new economy and discovered all sectors needed IT abilities (Philbin, 2014).

One goal of including computing in the national curriculum was to equip every child with the competencies they would need as adults to make ‘intelligent and informed choices about the digital technology that underpins their world and [and to make] valuable contributions to our digital society and economy’; this way, they could take their ‘proper place in a digitally enabled, knowledge-based society and economy” (BCS, 2010). The case for the digital economy was clear, although the hype may have underplayed the downsides to technological careers where jobs often come with a degree of fragility, complexity, and mundanity (Williamson, 2015).

11. Looking Back at Computing Education and Thinking Forward

As in previous decades, delivering new technology to schools today is an investment. In the 1980s, multiple government agencies funded training and equipment. By 2014, the UK government was providing only £3.5 million, the equivalent of £175 per school, to deliver this new 2014 curriculum. Teachers needed access to continuing professional development to acquire subject knowledge and adapt their teaching to the new computing curriculum; however, these accommodations were slow to materialise (Philbin, 2014). The computing curriculum made the UK a world leader as the first country in the G20 to recognise the importance of teaching young people computing. This eminence has had a lasting legacy for education, the country, and the UK economy (Woollard, 2018). The lingering question is not whether this legacy is a success or failure, but rather, to what extent did and does the UK's computing curriculum meet the ongoing needs identified prior to its implementation?

12. Postscript: Moving forward from here.

Since 2014, there has not been a new English curriculum, but the teaching of computing has continued. The establishment of the National Centre for Computing Education, funded by the Department of Education has started to fill the gap for training teachers (Teach Computing 2019). However, a 2020 survey of 100 Key Stage 3 and GCSE computing teachers found that teachers still found the curriculum dominated by teaching programming. While they value programming, they also feel it takes too much time (Mee, 2020). Many teachers find that with so much focus on programming, other aspects of ICT are being pushed out. In the primary school context, teachers find it challenging to implement key computing concepts when they are already trying to teach basic Maths and English in preparation for key exam points. There continues to be a lack of breadth and balance in computing (Mee, 2020), resulting in a subject that remains "inaccessible to most" (Mee, 2020). In terms of teaching programming, a key development in the research is Kallia and Sentance's (2017) investigation into "threshold concepts" in computing or concepts that are key to enabling learners' understanding of a subject or discipline (Kallia and Sentance, 2017). Understanding the threshold concepts can be essential to ensuring that teaching is effective, particularly as programming has come to dominate the teaching of computing. Working with teachers, they found that: "Arguments, calling a function, Control Flow, Parameters, Parameter passing, Procedural Decomposition and Design, Recursion, Return Values, Variable, Variable Scope, and Abstraction" are all potential threshold concepts (Kallia and Sentance, 2017). Others have recommended the integration of computational thinking into classroom activities in earlier years, deploying games, robots, and play to ensure a strong conceptual foundation (Lee et al., 2022).

There continues to be a need to understand computing education better as it is delivered. Falkner et al (2019) have developed a tool for examining the differences between the prescribed curricula and how they are enacted. This tool is of particular use (as it develops) to compare the differences between different countries' enactment of computing curricula (Falkner et al., 2019). This tool highlights how teachers remain the gatekeepers of computing, and their interpretation of the relevant curriculum is paramount (Falkner, 2019). While an understanding and use of computers will remain relevant, how this is tackled in education is worth keeping track of, as the intersection informs it of public policy and technological development.

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