The Impact of the English Computing Curriculum on Young People as Delivered at Key Stage 3

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Dedicated to my Wife.

Abstract

In 2014 the UK became one of the first countries to formally include computing in its National Curriculum Framework. The new Computing Curriculum had a broader focus, including fundamentals of computer science, computer programming and digital literacy in order to prepare young people for the digital economy and future digital world.

This doctoral research focuses on the impact of the new computing curriculum on young people at Key Stage 3, particularly using three core themes of the computing curriculum: digital economy, digital literacy, computational thinking. The analysis used these core themes with thematic coding to answer the research question: To what extent do the young people subject to the English computing curriculum (as delivered at Key Stage 3) and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

The research fieldwork was conducted across 3 secondary schools in the northwest of England and comprised of qualitative group interviews with 54 young people and extended individual interviews with 9 teachers. This research found that young people did not feel the computing curriculums was adequately preparing them for the digital economy – specifically they did not feel they were learning to be digitally literate and considered that computational thinking was something that people were either naturally good at or not.

This thesis contributes to the field of Computing Education by being one of the few studies to use qualitative methods to understand young people's experience of computing education.

Anonymised data and other documentation related to this thesis can be found here
URL: https://dx.doi.org/10.17635/lancaster/researchdata/367

Declaration

This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy. This thesis has not been submitted in support of an application for another degree at this or any other university. It is the result of my own work and does not contain any materials previously published or written by another person except where due reference is made in the text. No part of this thesis has been previously published in any form. The following works drew on my experience and research conducted as part of the process of producing this thesis.

All research activities for this study were carried out in full compliance with Lancaster University's ethics guidelines.

Academic Publications:

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Other Publications and Articles:

Hello World – **Digital literacy** - https://helloworld.raspberrypi.org/issues/4 (Jan 2018)

The Conversation - **Coding the curriculum: new computer science GCSE fails to make the grade** - https://theconversation.com/coding-the-curriculum-new-computer-science-gcse-fails-to-make-the-grade-79780 (June 2017)

The Conversation - **How Artificial Intelligence and the robotic revolution will change the workplace of tomorrow** - https://theconversation.com/how-artificial-intelligence-and-the-robotic-revolution-will-change-the-workplace-of-tomorrow-72607 (March 2017)

The Conversation - **When it comes to computing, rural schools are at risk of being left behind** - https://theconversation.com/when-it-comes-to-computing-rural-schools-are-at-risk-of-being-left-behind-57861 (April 2016)

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Preface and Motivation.

What follows is an academic study, and as such it endeavours to follow academic conventions, including using third person prose to explore the research topic. Before switching to this more formal style, I wanted to take this opportunity discuss my motivation for the study and the approach. As a former youth worker, and current school governor and parent, my approach to this research was deeply informed by my personal experiences. While I have taken every care to ensure that my personal views have not impacted on the findings of this thesis, I would not have started down this road without this background. During the time of the research, I have continued to get to know teachers who teach computing and have run computing clubs in my local areas. The topics covered in this thesis deeply impact these people I know well. The research for the thesis involved interviewing young people in year 9. During the period of this research from 2014-2020, my own child completed the school years of 7-11, so was experiencing the very phenomenon I was studying, although was not part of the research.

This thesis looks at the implementation of the 2014 English computing curriculum. England was one the first countries to include computing as part of the national statutory requirements, requiring pupils from the age of 4 to 15 to learn aspects of computing. This included learning aspects of computer programming, computer science, and computational thinking alongside many of the digital literacy skills that had been included in what was formally known as ICT.

From my personal experiences with people in education, I was struck by how absent the voices of both young people and teachers were from the discourse regarding computing education and the new curriculum. While much weight was given to the words of Minister for Education (Michael Gove) that students thought of ICT as boring, there was little evidence that the views of young people had been explored either before, during or after the implementation of the new curriculum framework. It seemed very clear that the curriculum was something that was 'done-to' teachers and young people - not a process where either population was included, consulted or even (it seemed) considered. During the research process, it became clear that while teachers, through Computing at School had been instrumental in ensuring a computing curriculum was on the agenda of the Department for Education, much of what they had recommended was in the end discarded. The voices of the young people, on the other hand, were almost entirely absent - even while their futures, outcomes and lives were being shaped and legislated.

As I started this research, I drew inspiration from scholars such as Paul Willis, whose "Learning to Labour" (1977) explored the lives of working class kids as they engaged in the British education system, Julie McLeod and Lyn Yates whose "Making Modern Lives" (2006) followed the lives of young people over the course of decade to see the impact their schooling had on their lives and identity (far beyond their academic success), and finally Sonia Livingston and Julian Sefton-Green whose "The Class: Living and Learning in a Digital Age" that looked deeply at the lives of young people from a single 'class' in inner city London. While it was far beyond the scope of my work to conduct a study that compared to any of these works, I took from these studies the importance of placing young people's voices at the heart of an academic work, specifically a work that considered English legislation which was directly impacting their lives.

In simple words, I approach this study with a question - could I represent the impact of the English computing curriculum on young people using the words of the young people themselves. The data for this study was rigorously collected, analysed and is presented here. I have done my best, where possible, to use the words of the young people themselves to express their response to the curriculum. I knew from the beginning of the study that views and experiences of young people are limited, and therefore chose to also interviews their teachers, to add depth and perspective.

I hope that what follows does justice to the thoughts and feelings of the young people and teachers who participated in this study. I strongly feel it is shame that these voices are so often absent from discussions of curriculum change and development, as I personally can attest that their insights are truly invaluable to this discourse.

Chapter 1: An Introduction

1.1 Introduction

In October of 2013, the then United Kingdom's coalition government published the new 2014 National Curriculum (Gov.uk, 2013). While this document changed many aspects of education in England, this document replaced the subject of ICT (Information Communications Technology) with the new subject of computing. While there are many similarities between ICT and Computing - computing, for the first time in a statutory education in England, drew substantially from the academic field of Computer Science. Computing went beyond just Computer Science and instead aimed to equip young people with the digital literacy they need to be successful in the digital economy and a broader digital world.

The new curriculum (DfE, 2013, online) set out to create a "high-quality computing education" that would equip "pupils to use computational thinking and creativity to understand and change the world." The newly created subject area was seen to have links to areas such as "mathematics, science and design technology" and could help young people understand "both natural and artificial systems." While similarly to the ICT curriculum, "Computing also ensures that pupils become digitally literate – able to use, and express themselves and develop their ideas through, information and communication technology – at a level suitable for the future workplace and as active participants in a digital world." It differed significantly from ICT in that "The core of computing is computer science" and the explicit addition to requiring pupils to understand "the principles of information and computation, how digital systems work and how to put this knowledge to use through programming".

While the National Curriculum is an abstract document, it impacts the real experiences of young people. While the curriculum aims to prepare young people "for the future workplace and as active participants in a digital world"—as this study will go on to show—young people are already participants of this digital world. From an early age, young people are surrounded by digital devices, and as teenagers, they already live complex digital lives. The contents of their computing lessons are not just about a future point when they may need the knowledge and skills of computing but are things that they can apply the minute they leave the classroom. The National Curriculum states:

> The National Curriculum for computing aims 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
> - Are responsible, competent, confident and creative users of information and communication technology. (DfE, 2013, online).

It can be argued that as active users of digital devices and participants of a digital world, by the time young people have entered secondary school, they will be able to apply these aims immediately to their daily lives.

Aims and Objectives.

This thesis takes the stance that in order to understand how the curriculum has impacted young people's lives it is imperative to speak to young people themselves about their own experiences. This thesis aims to examine how the curriculum has impacted the lives of young people by asking them about their experiences of computing education. This study has chosen to look at the final point of Key Stage 3 (year 9 in English schools) before young people choose their options for their GCSEs deciding what subjects they will continue to study at a higher level. The research for this study took place in the June and July of 2016 and January of 2017 when the young people had studied computing under the new curriculum for the past two years (their entire time in secondary school). While this period continued to be a point of transition for teachers delivering computing for the young people involved in this study, they had only known computing at secondary school. As the research shows, their experiences of computing had already shaped their understanding of the world and their choices about the future. Computing lessons also shaped their understanding of the subject itself and of Computer Science as they began to choose whether they would want to continue the subject.

Research Question.

To what extent do the young people subject to the English computing curriculum as delivered at Key Stage 3 and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

Sub Questions.

1. How do KS3 pupils and teachers understand the digital economy and broader digital world and how are the pupils understanding being shaped by the delivery of 2014 computing curriculum?
2. Do KS3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?

3. What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?

By developing an understanding of this research question and sub-questions, this thesis aims to better understand the context of the computing curriculum and its impact on young people.

This doctoral thesis has been written as part of the High Wire Centre for Doctoral training funded by UK Digital Economy Theme to pursue cross disciplinary research in the digital economy. This thesis would not have been possible without developing a cross-disciplinary approach to researching computing education.

Computing education is a quickly developing field, and over the course of the completion of this Ph.D. much has changed, and this field will continue to change. This thesis can only be something of an introduction, a beginning, a snapshot of a beginning of when a new subject was introduced to the English National Curriculum which aimed to prepare young people for a digital future.

This thesis will proceed as follows: Chapter 2 will look at the history of computing education in England and develop the justification of the use of the three themes used throughout the research. Chapter 3 examines the literature surrounding the three themes of the thesis. Chapter 4 presents the methodological approach used in for this project. Chapter 5 presents the data from group interviews with young people and Chapter 6 presents the data from the extended interviews from teachers. Chapter 7 is the discussion of the data, presenting, recommendations and the data is validated through expert interviews. The final chapter, Chapter 8, presents the limitation of the study, potential future work, and the thesis's contribution to knowledge.

Chapter 2: An Introduction to Computing Education

2.1 Introducing the History, Influence and Themes of the Computing Curriculum.

The focus of this PhD is the effects and impacts of the 2014 English computing curriculum specifically on young people in Key Stage 3 in the English educational system. The majority of this thesis will be focusing on the contextualisation of how computing has been taught at Key Stage 3 (when the young people are usually age 13 – 14) and the key themes of digital economy, digital literacy, and computational thinking that emerge from the literature.

This chapter sets out to provide context and justification for the three themes of investigation, to give the reader a brief introduction to the forces which shaped the 2014 computing curriculum and why a new approach was thought to be needed, and to present a brief history of what computing education in England looked like prior to 2014. This chapter will then progress to consider factors that shaped the 2014 computing curriculum.

The final section of this chapter will look at why the three themes of digital economy, digital literacy, and computational thinking are leading to valuable insights about the teaching of computing in schools.

2.2 A Brief History of Computing and ICT in Schools

It was only with the introduction and proliferation of affordable home computers that it became a necessity that schools address and then embrace this new technology. At several points in this history, the drive to have computers in schools was motivated by the anticipation that computers and technology were becoming a driving force for the UK's economic future.

This section sets out to give a brief overview of how the formal subject of IT, ICT, and computing became a strategic part of the UK compulsory education. It examines the early genesis of computers making their way into schools, then looks at what computing in schools looked like in the 1980s, and how different forms of computing were integrated in various versions on the National Curriculum for England and Wales. The next section of this chapter will look at the development of the 2014 computing curriculum in more depth.

Formally, the teaching of computing in schools starts 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 opened up the possibility of pupils seeing computing as a potential career and something that could be studied at school.

The potential (or impact) of computers on everyone's future was further highlighted in 1978 with the broadcast of a Horizon television programme *Now the Chips are Down*, which made dramatic predictions about how computers and microchips would be replacing human jobs in the near future (Anderson & Levene, 2012, p. 18). These dire predictions may have been over dramatised, but it highlighted how computers were seen as a powerful driver of the future economy, and individuals would need to learn a new set of skills to remain relevant. Computers were being seen as a transformative technology, reshaping society.

By the late '70s and early '80s, the cost of computers was coming down dramatically with a number of companies (specifically in the UK) making computers for a mass market. By the early '80s, there was a personal computer with a QWERTY keyboard available for less than £100 released by Sinclair (Anderson & Levene, 2012, p. 26; Haddon, 1991, p. 163).

Computing technology began making its way into schools and were embraced by teachers of mathematics, as there was a clear link between the computer, mathematics, and logical problem solving. Over time, in some schools, teachers in other disciplines became interested in the potential of using computers in their subject (Passey, 2014, p. 133).

At the same time, the UK government began to see competing in the information economy as essential for economic success, and a skilled workforce as paramount to this aim.

By 1986, education was seen as being the dominant factor in ensuring Britain success in the world-wide information society (Lyon, 1991, p. 93). Microelectronics and computing became presented as essential to the economic success of the UK, and economic utility presented as educational usefulness, and as such, technology became a necessary part of both teaching and learning (Linn, 1991, p. 201).

The UK introduced the first National Curriculum in 1989, and while this new curriculum did not include computing specifically, it did encourage schools and teachers to use Information Technology across the curriculum. It wasn't until the 1998 reform of the curriculum that every pupil would be learning about IT (Passey, 2014, p. 134–135).

2.2.1 The Beginnings of the Relationship for Computers and Schools

The earliest versions of computing in UK schools were rudimentary but included many of the themes that re-emerged in the 2014 curriculum. Computing in UK schools focused on how the technology worked, some programming, and some uses of commercial application, while using computers to assist other learning was rare and only taken up by enthusiast teachers rather than as any part of a greater strategy (Woollard, 2014, p. 14).

This changed as there grew a greater concern that there was a potential alignment between industry and education in terms of ensuring that young people had the computer skills they would need to enter the work force and ensure the UK's economic success into the future (Passey, 2014, p. 132). By the late '70s a number of computers had been developed and aimed at the school market. Research Machines (RM) developed microcomputers for schools, and the Apple II and the Commodore Pet came out at a similar point and aimed at the education market (Passey, 2014, p. 133). These computers were appropriate and available but were still seen as prohibitively expensive. Due to the high cost of machines such as the RM 380Z, most schools were not able to invest in the new technology. It was not until the

1980s when a number of government programs came into place that made it possible for schools to begin to buy computers. Specifically, both the Department of Education and School (DES) and the Department of Trade and Industry launched initiatives to fund computers and computing in schools (Passey, 2014, p. 133).

Prior to the 1980s in the UK, while there was some desire to integrate computers into the classroom, there was not yet the strategic intention, the available technology, or the available funding and resources for this to be anything more than the exception. However, from the late ‘70s and early ‘80s, these strands came together very quickly to see a large proliferation of computing in schools in varying degrees.

2.2.2 The ‘Golden Age’: Computing in schools in the ‘80s

While computing as something that should be taught in schools got off to a slow start, by the time the 1980s came around there was something of an explosion of interest and funding. There was still a great deal of mixed messaging around what the ‘purpose’ was of this new subject. While some of what was taught focused on problem solving and computer programming, there was also a great deal of focus on how to use applications. Throughout this decade, there was a shift from ‘learning to program’ as being the key to national and personal economic success. By the end of the decade with the introduction of the National Curriculum in 1989, focus became more on learning how to use computers more generally (Woollard, 2018, p. 14).

As exemplar of the hype and promise of the early ‘80s, the BBC released the BBC micro and accompanied it with a series of television broadcasts called the *Computer Literacy Programme.* The impression was very much that children who knew how to code would have a significant advantage over those who did not. This impression was reinforced by a number of news stories about ‘whizz-kids’ who were already making a living from computer programming even before leaving school (Anderson & Levene, 2012, p. 53).

The BBC was not alone in investing resources into getting children to code. Leading on from the challenges which came to light at the end of the previous decade, several government initiatives came to be which put funding into raising awareness about computers and computing skills, getting computers into schools. In this period, a number of television programmes broadcast in the early ‘80s brought the idea of computers, and more specifically, computer programming into British living rooms. Computing became something anyone could do and ultimately something everyone should do (Anderson & Levene, 2012, pp. 46–47; Webster et al., 1991, p. 71).

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 both on the potential of technology to transform society while equally encouraging the public to learn how to use technology, specifically, young people (Webster et al., 1991, p. 72).

By the mid ‘80s, there was demand from schools for national funding to invest in equipment, technology, and capacity. Soon funding was provided for teachers to receive training regarding the new developments in IT (Passey, 2014, p. 134). The Department of Trade and Industry (DTI) provided significant funding to get more computers into schools but also funding additional aspects needed for computing such as telephone lines for data communication. The DTI funding mainly focused on hardware that was manufactured in the UK such as the RML 380z, BBC Acorn, and the Sinclair Spectrum (Linn, 1991, p. 209; Passey, 2014, p. 133). By the end of the decade, DTI funding was being used to purchase computers, disk-drives, mice, monitors, teletext adaptors, and Turtle robots. By the early

‘90s, most schools had computer networks that could allow links between schools and regions (Passey, 2014, p. 134).

While the DTI was funding hardware, the Department of Education and Schools (DES) and the Department of Employment funded the “Microelectronics in Education programme” and the “Technical and Vocational Education Initiative” respectively focusing on preparing young people for a future society where computers would be common place, specifically through training for teachers and young people alike (Linn, 1991, p. 208; Passey, 2014, p. 134)

Very quickly within this period, computers in schools were becoming common place. Due to the 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, p. 40).

While the aim was for computers and IT to be used across the curriculum, schools did not always develop IT as a subject in itself. Instead, the computers were mainly in computer labs, and subject teachers (who were not IT teachers) found they had limited access to technology-based resources. “Even so, from 1989, the idea of IT ‘across the curriculum’ was felt by many advisers and teachers to be worthwhile, but practically difficult to achieve” (Passey, 2014, p. 144).

With the approaching publication of the new National Curriculum in 1989, more and more emphasis was put on using IT across the curriculum and for schools to develop effective strategies to use IT to enrich the entire curriculum. There was an increasing focus on producing topic-based resources and software (Passey, 2014, p. 144). The arrival to the Windows operating system saw the take up of authoring multimedia technologies as a core part of IT, as it made multimedia tools accessible for schools and young people (Woollard, 2018, p. 14).

During the launch of the National Curriculum in 1989, the pressure for computing and IT to be used to enhance all of learning became explicit with the stated aim that the curriculum should ensure that every pupil use IT to enhance learning in every subject (Passey, 2014, p. 144). Not only did the National Curriculum make it explicit that every pupil should be using computers and IT across their learning, it also specified what this should look like (Woollard, 2018, p. 14).

In terms of computing education, the 1980s started with something of a free-for-all with a large amount of money and excitement rapidly increasing the potential for pupils to learn about and with computers. Much of the early focus was on learning computer specific skills such as logic and even programming. By end of the decade, much of the excitement seems to have faded. The government initiative 'IT82' was all but forgotten, and the focus had moved to using computers to learning how to use computers, rather than learning how they worked, how to make them work, or how to write one's own programs (Passey, 2016, p. 2).

2.2.3 National Curriculum in 1989, 1998, and 2004

In the narrative of computing in school and the greater story, education in England and Wales in 1989 must be seen as a watershed moment as the National Curriculum significantly changed education across the country. "For the first time, subject content was specified for all sectors of compulsory education, and the specification of this content was a learner entitlement curriculum that was statutory" (Passey, 2014, p. 135).

In the first version of the National Curriculum, IT was not a separate subject area but was integrated in the design technology. The use of technology to a greater or lesser extent was included in every subject area of the curriculum and at every age level; however, the primary focus was within design technology (Passey, 2014, p. 135). Despite not having its own curriculum area, IT was given five specific strands of progression called ‘IT Capability’. These included developing ideas and communicating information, handling information, modelling, measurement and control, application and effects (Barnes & Kennewell, 2018 p. 28; Passey, 2014, p. 135).

These themes demonstrate a movement away from controlling computers to using computers (form understanding computers and programming to using specific software). This version of the National Curriculum lasted for approximately another decade, seeming to stabilise, formalise, and institutionalise how IT was used in schools.

However, by the end of the ‘90s, this stagnation was being recognised. With the change of government in 1997, minsters began to openly discuss how to link uses of IT to their wider concerns about learning, attainment, and effectiveness. IT was being discussed as a way to raise standards across all subject areas (Passey, 2014, p. 144). The Stevenson report (also published in 1997) raised concern regarding basic IT confidence and competence among both teachers and pupils as well as the need for stability of policy towards computing learning (Woollard, 2018, p. 15).

These concerns provided the groundwork for the curriculum reform in 1999 to revisit IT with the creation of the discrete subject of ICT (Information and Communication Technology). 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, web site or hypertext link,*
- *Processes such as developing a presentation, seeking information, 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 and evaluating, the result reflecting on the effect of using ICT in particular situations. (*Barnes & Kennewell, 2018, p. 29)

These five capabilities further moved the curriculum away from programming and toward applying ICT to specific (often work-related) tasks. Computers had moved from being a 'new technology' to be explored and investigated; repurposed and reprogrammed — to being tools which would be essential for any future of work a child might imagine. While many of the concepts that might be associated with Computer Science do occur, these are all pushed into the final capability, that also focuses on "reflecting on the effects of using ICT in particular situations", choosing the right tool for the right task, rather than making one's own tools (Woollard, 2018, p. 15).

By creating a discrete subject area for ICT, the 1999 curriculum, on one hand, meant specific time could be set aside for the teaching and learning of ICT, but it also took the emphasis away from the use of ICT across the curriculum. By 2002, the focus was once again on computer suites in primary schools and specialist teaching in secondary schools (Woollard, 2018, p. 15). Throughout this period, the greatest challenge to computing across the curriculum was seen to be teachers' attitudes toward using emerging technology (leading to IT skills only being taught and used in IT lessons), but by 2004, there was again the "re-emergence of the ICT across the curriculum" as part of the secondary school strategy (Woollard, 2018, p. 15).

Therefore, while there was a relative stability in IT provision after the initial National Curriculum in 1989 to 1997, once this provision was brought into question, several different approaches were either proposed or attempted with the attempt to answer questions such as: when it comes to computers in schools, what should be taught (programming, IT, ICT); why should it be taught (for industry, for work, for any other reason); should it be discrete and or cross curricular?

By 2008, a number of pieces moved into place to attempt to answer these questions and start to lay the groundwork for the 2014 curriculum with its focus more on Computer Science than ICT or IT.

2.3 Where Did the 2014 Computing Curriculum Come From?

Having reviewed the history of the teaching of computing and ICT in schools, this next section will look more specifically at the context out of which the 2014 Computing Curriculum arose. Young's observation from 1991 continues to hold relevance:

> *Discussions about technology in education are characterised by the abstractness and extreme diversity of focus. They are frequently polarised between the perceptions of two groups who understand little of each other. These are the specialists, often but not always in electronics of computing and the rest who have little concrete knowledge of either (or any other) technologies. (p. 234).*

Throughout the process of curriculum development, these tensions remain apparent. Much of the curriculum change was advised by a range of experts and specialists, but these recommendations were often contradictory and were then implemented by non-experts (Williamson, 2015, p. 40). One of the key themes of this point was that there was a considerable agreement that it was desirable that something like Computer Science should be (re)introduced into the compulsory curriculum (Passey, 2016, p. 8). Before digging into this intention, it is worth remembering that the discipline of Computer Science is a relatively new addition to post-compulsory education, with the first departments of Computer Science in universities only arising in the early 1960s and the first Doctor of Computer Science being awarded in 1965 (Passey, 2016, p. 2). This is worth noting for two reasons: the knowledge of what makes up Computer Science is not cemented into place or clear to a general perception in the way a subject such as maths might be; secondly, one of the arguments for a new curriculum was a “a collapse in student numbers applying for university courses in Computer Science” (Peyton-Jones, 2009, p. 2).

Prior to 2014, pre-sixth-form compulsory curriculum in England mainly emphasised ICT literacy focusing on a small number of applications (Peyton Jones, 2009, p. 5). “As the computer has become more ubiquitous, the attractiveness of learning ICT had seemed to decrease” (Peyton Jones, 2009, p. 5).

Much of the intention of the revision of the computing curriculum was to reinvent the topic so that it could appeal to a wide range of students—Computing could be seen as applying to every aspect of life and could be tied to almost any student interest (Peyton Jones, 2009, p. 11).

Before looking at the creation of the curriculum, it is worth standing back and observing that alongside the launch of the new curriculum in 2014, there was a parallel to the efforts of the early 1980s to raise the awareness of the potential of computer programming. The UK government established the “Year of Code” campaign in 2014, linking the ability to write computer programs to potential economic success (Williamson, 2015, p. 46).

This section will look at the following: the organisations and reports that advocated for a change of curriculum; the various arguments for a revised curriculum; why Computer Science was seen as the missing aspect of pre-2014 curriculum and some of the arguments for keeping aspects of ICT; and finally, a brief view of how alternative agendas may also have had a influence over the creation of the computing curriculum.

2.3.1 CAS, Restart, and NexGen: Voices all Shouting for Change

The computing curriculum was strongly influenced by a number of factors including grass roots organisation (CAS), two independent reports, with the final catalyst for change being a speech by a global industrialist.

Already in 2008, a group of academic industrialists and teachers were coming together to form an organisation called CNG (Computing Next Generation), which later evolved into the group Computing at School (CAS) (Woollard, 2018, p. 15). Computing at School started as a newsletter and a regular gathering of a small number of teachers. Over time, it became a coming together of a range of individuals, many of whom were frustrated by the lack of Computer Science in the National Curriculum (Davies, 2017). The membership of CAS was primarily made of up enthusiastic teachers, many of whom had previously had the freedom to include some aspect of Computer Science in their lessons, academics who were concerned with the drop in applications to study Computer Science programs at universities across the UK, and representatives of industry from a small number of large technology companies who were concerned by the lack of knowledge of higher level Computer Science (BCS, 2010, p. 3; Peyton Jones, 2009, p. 17; Sentence & Csizmadia, 2015, p. 245; Williamson, 2015, p. 45; Woollard, 2018, p. 21). CAS received funding and support from the British Computing Society (also known as the Charter Institute for IT), and by 2010, started to publish white papers (BCS, 2010; Computing at School, 2010; Computing at School Working Group, 2012; Peyton-Jones, 2009), proposing a rethink of how computing needed to be taught in UK schools (Williamson, 2015, p. 45).

In the early white papers, CAS presented the distinction between ICT as being a skill, and Computer Science being a discipline with deeper implications and applications. CAS was very critical of the focus on ICT, making the case that while ICT was very important, it was also equally important that every child be introduced to Computer Science, even if not every child would eventually make use of the concepts they learned (Peyton Jones, 2009, p. 2). The position of CAS was that there had been a back slide motion away from pupils being able to learn computing compared to previous generations: “No one disputes the importance of ICT; but an 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, p. 2).

CAS drew the connection between the dropping numbers of students pursuing computing and the problems with recruitment for employment in computing careers and directly connected this to the Key Stage 3 curriculum which was too closely associated with learning how to use ‘office-type’ software and no longer seemed to contain opportunities for creativity (for example, through programming) or an understanding of how computers work (Woollard, 2018, p. 21).

Almost at the same time as CAS started to advocate for a more comprehensive approach to Computing and Computer Science in schools, two reports were published which reviewed the state ICT in schools and argued for a revision of the ICT curriculum. The first of these was the “Next Gen” report published by Nesta and written by Livingston and Hope (2011). Next Gen specifically aimed to look at the connection between the computing skills young people learned in school and the digital economy (Livingston & Hope, 2011, p. 5). Specifically looking at the video game and visual effects industries in the UK, Livingston and Hope examined whether young people were learning the skills and concepts they would need to enter these industries (Livingston & Hope, 2011, p. 5). One of the key messages of this report was that young people needed to learn to code and have a rigorous knowledge of computing, advocating for Computer Science to be central to the National Curriculum (Livingston & Hope, 2011, p. 82; Williamson, 2015, p. 45). However, Livingston and Hope also advocated for the importance of linking the Arts and Computing and for the Arts to also take a central place in UK schools (Livingston & Hope, 2011, p. 82). This emphasis of Arts is worth noting as this call was also repeated in Eric Schmidt's (2011) MacTaggart lecture (see below), but in both cases, it was overshadowed by the call for Computer Science.

Royal Society, also released a report called "Shut down or Restart? The way forward for computing in UK schools", that called for the reintroduction of Computer Science to UK schools, harking back to when the BBC micro introduced a generation to the ideas of programming and Computer Science (Royal Society, 2012 p. 3; Williamson, 2015, p. 45; Woollard, 2018, p. 15). Written by Steve Furber, who had been part of the team which developed the BBC micro in the first place (Anderson & Levene, 2012, p. 40; Royal Society, 2012, p. 2), "Shut Down or Restart" was directly commissioned by Microsoft, Google, and a number of University Computer Science departments (Williamson, 2015, p. 45). This report was also very critical of the state of ICT in UK schools, stating, "The current delivery of Computing in UK schools is highly unsatisfactory" (Royal Society, 2012, p. 5), mainly because:

> *1.1 the current national curriculum in ICT can be very broadly interpreted and may be reduced to the lowest level where non specialist teachers have to deliver it;*
>
> *1.2 there is a shortage of teachers who are able to teach beyond basic digital literacy;*
>
> *1.3 there is a lack of continuing professional development for teachers of computing;*
>
> *1.4 features of school infrastructure inhibit effective teaching of computing.*

While these two reports and the on-going work of CAS were seen as instrumental to the revision of the Computing curriculum, the key catalyst is generally considered to be Eric Schmidt (the then head of Google) giving the 2011 MacTaggart Lecture (Woollard, 2018, p.

15). Schmidt's (2011) speech is widely seen as the event which mobilised political support for the reform of how computing needed to change, bringing into relief (some of) the conclusions of both "Next Gen" and "Shut down or restart" (Williamson, 2015, p. 45). Schmidt (2011) used this platform to express his dismay at the state of Computer Science in UK schools, stating that it was hard for Google to find the talent they needed in the UK (Cave & Rowell, 2014, p. 244; Williamson, 2015, p. 45). Schmidt (2011) metaphorically threw down the challenge for the UK government stating, "Your IT curriculum focuses on teaching how to use software but gives no insight into how it's made. That is just throwing away your great computing heritage". The Next Gen report had called for the Arts to be alongside Computer Science (Livingston & Hope, 2011), Eric Schmidt (2011) had said "First you need to bring art and science back together", and the Royal society report had also emphasised the need for Digital Literacy (Royal Society, 2012).

With these comments, politicians and commentators were prompted to openly rebuke the teaching of ICT and call for more Computer Science (Williamson, 2015, p. 45). Michael Gove (2012), the then minister for education, gave a speech at the BETT exhibition in 2012 openly calling ICT "harmful, boring and / or irrelevant" and promising to reform the teaching of computing in UK schools to be relevant for the future, promising to include a rigorous approach to Computer Science in the new National Curriculum. Gove (2012) made it clear that the stated goal of the new approach of the computing curriculum was to move away from ICT and towards Computer Science, taking input from Nesta, BCS, Google, Microsoft, Computing at School, and Raspberry Pi (Williamson, 2015, p. 45).

While the confluence of various forces came together to make Computer Science appear more appealing than ICT to schools and young people, most of these reports and speeches (with the exception of Michael Gove) called not for the replacement of the skills taught in ICT with Computer Science but rather a supplementation. Recalling Young's (1994) observation about specialists and non-specialists influencing the use of technology in schools, in this case, the specialists called for a computing curriculum that, yes, included Computer Science but also “drew on” digital literacy, ICT skills, and the Arts. Probably more importantly, the “Shut down or Restart” report stated, “Computer Science is sufficiently important and foundational that it should be recognised as a high-status subject in schools, like mathematics, physics or history” (Royal Society, 2012, p. 31).

Taking this statement seriously would have meant giving the subject of computing a much larger portion of a child’s school day possibly allowing for the delivery of both ICT, Digital literacy, and Computer Science. Instead, while the content changed, the amount of time devoted to “computing” at most secondary schools remained more or less the same (approximately one hour week for the schools included in this thesis) (Kemp & Berry, 2019, p. 1). The message of the 2014 computing curriculum was clear: ICT is out; Computer Science is in.

2.3.2 Why so much Computer Science?

While the political context of the 2014 computing curriculum was clearly in favour of a move towards Computer Science, this section will look in more depth at the concrete arguments for why a shift towards Computer Science might have been necessary. As was shown previously, these decisions about computing and Computer Science and their place in the statutory curriculum are nothing new, and while this thesis is specifically looking at the UK experience, countries around the world are grappling with the same question (Passey, 2016, p. 2).

As was demonstrated in the previous section, there were a range of arguments made for why the ICT curriculum was no longer fit for purpose. While on one hand CAS made the argument that ICT provision, while serving some students well, was actually holding the more able students back (Peyton-Jones, 2009, p. 6). Moving towards using Computer Science is moving 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, p. 3). What both these arguments have in common is that they are almost entirely focused (or mostly relevant to) the most able students. And they fail to ask: What about the students who need to do the jobs that do already exist? Or need to use the technology which has been invented?

Passey (2015, pp. 28-30; 2016, pp. 5-7) puts forth six specific arguments for why a more comprehensive Computer Science curriculum might be relevant for all students:

1. The economic argument: education should prepare pupils for the future economy, with the skills need for current and future jobs and skills requirements.
2. The organisation argument: there are skills such as collaboration and teamwork, that although not specific to Computer Science can be linked to Computer Science.
3. The community argument: that computing facilities and computing skills have become increasingly essential for engaging in communities.
4. The education argument: computing technology is ever developing and if young people are not given a 'base line' of learning they will be left behind.
5. The learning argument: pupils will need their computing skills in order to access learning both in school and also independently.
6. The learner argument: pupils should learn in school not just subjects that are 'useful' such as numeracy and literacy, but also areas that interest them.

While these arguments also seem to create a compelling argument for the inclusion of Computer Science, in fact, as Passey himself points out, these six arguments can equally apply to ICT (Passey, 2015, p. 30). He points out that while it is easy to say the curriculum "should" shift in one way or another, it is important to consider what this may imply for schools, teachers, and the learners themselves (Passey, 2015, p. 40). In the case of Computer Science, it is often reported by lecturers that students do not find it an easy subject and often report it as hard (Passey, 2015 p. 29; Passey, 2016, p. 11), and while this may seem a spurious argument, considering that computing was being required to fit in the same time table as ICT had fit within, but is a 'harder' subject, it seems self-evident that many pupils will find it more difficult to make progress and may find the subject more frustrating. At the same time many of the ICT skills remain important for pupils' futures, and an entire shift from ICT to Computer Science could potentially mean competencies gained from ICT could be lost; this suggests that some sort of balance would be needed rather than a wholesale shift from one to the other (Passey, 2015, p. 41). The question that remains is whether schools have the facilities to enable teachers access to use technologies to support both ICT and Computer Science (Passey, 2015, p. 41).

This argument of not one or the other but both is actually closely mirrored by the final conclusions of the "Shutdown or Restart" report from the Royal Society (2012):

- *Computer Science is sufficiently important and foundational that it should be recognised as a high-status subject in schools, like mathematics, physics or history.*
- *Every child should be expected to be "Digitally Literate" by the end of compulsory education, in the same way every child is expected to be able to read and write.*

- *Every child should have the opportunity to learn concepts of and principles from Computing (including both information technology and Computer Science) from primary school age onwards, and by the age of 14 should be able to choose to study towards a recognised qualification.*
- *Pupils should be exposed to, and should have the option to take further, issues such as understanding the internet and design of web-based system, the applications of computers in society, business, science and engineering, computer programming, data organisation and the design of computers and the underlying principles of computing*. (p. 31)

The wording of these findings is important: 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. If we were to look at the wording alone, it would seem that the most important aspects would be to value (and, therefore, give more time to) computing lessons and ensure every child is digitally literate, while the second two points provide opportunities which pupils can choose to engage in or not.

While theoretically by 2014, the momentum had built up to shift computing away from ICT and towards Computer Science, it is not entirely clear that the costs of such a shift had been fully appreciated.

2.3.3 Reflecting on the Case for a New Curriculum.

The questions remain, then: What was the main purpose of the curriculum change, and looking back what has been the effect? This thesis will be exploring this further. One of the things to reflect on is that within the CAS white paper from 2009, the case was made that, in fact, much could have been achieved with the exciting KS3 curriculum:

> *Furthermore, the National Curriculum Programme of Study at KS3 is admirably non-prescriptive. Much that we have described as "Computing" could readily fit within it, and some is mandated (e.g. "Use ICT to make things happen by 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, p. 13)

If this was the case, then the circumstance for change was not for a new curriculum but rather for a new approach to the existing curriculum. Williamson, on the other hand, proposed that some of the purposes of the new curriculum was to imbed a new way of thinking about the world; in fact, computational thinking and thinking through code would change how young people think and relate to the world, relating to phenomena they encounter as things that can be described in code and understood as computable phenomena (Williamson, 2015, p. 49). Williamson's stance is that it is to the advantage of large technology companies and government systems that pupils understand the world through computers. An overarching question, then, is whether a new curriculum will provide a solution to the problems seen as inherent to the ICT curriculum:

> *Changing the curriculum does not necessarily change those features of the teaching of ICT that caused the decline in numbers pursuing Computer Science to a higher education and vocations.* (Woollard, 2018, p. 22)

2.4 Three Themes of Forward Motion: Computational Thinking, Digital Economy, and Digital Literacy

This section will examine computational thinking, digital economy, and digital literacy as the main themes which motivated the development of the new curriculum to some extent. Looking forward to the 2014 computing curriculum (DfE, 2013), underlines the importance of each of these themes, explicitly mentioning computational thinking, and digital literacy while heavily implying the relevance to jobs in the digital economy.

As was demonstrated in the previous section, the advocates for a revised curriculum in regard to computing came from a number of different organisations. The final version in the curriculum had gone through a number of iterations, and while the focus on computational thinking, Computer Science and programming remained (or had been amplified), much of the proposed content regarding areas relating to creativity, criticality and digital literacy had been removed (Williamson, 2015, p. 47).

Regardless, the core of the computing curriculum remained focused on three areas drawing from the three arguments made for the reformed approach. CAS had primarily made the argument for computational thinking to be the core of the curriculum, drawing on Computer Science but allowing the tools of Computer Science to be utilised in a wider range of ways (Peyton-Jones, 2009, p. 5). "Shut down or Restart" had made the case for digital literacy remaining the basic skills necessary for all pupils (Royal Society, 2012, p. 18). The "Next Gen" report from Nesta had focused on the needs of the digital economy, highlighting the skills shortage and the need for a pipeline of new talent to ensure the UK's continued economic success (Livingston & Hope, 2011, p. 8). While there is a great deal of overlap between the arguments for each report and organisation, these three areas (computational thinking, digital literacy, and the needs of the digital economy) can be seen consistently as the three main arguments for reform of the curriculum. The following sections will look at the arguments regarding each of these areas.

As has been noted, the final version of the curriculum focused more on computational thinking and Computer Science than on digital literacy or the needs of the digital economy. The arguments for the neglected areas did not go away, and the anticipation was that in one way or another, young people would learn digital literacy and be prepared for the digital economy either through informal learning, other lessons, or indirectly. The new curriculum moved away from the functional skills that had been characterised by ICT curriculum and focused on computational thinking and Computer Science with a significant focus on computer programming (Williamson, 2015, p. 47). Computer programming sits at the nexus of the three arguments for computing as it can be argued that it is related to any of the three areas of focus. While at the same time, there does not tend to be an argument that 'programming' should be learnt for its own sake rather than being learnt as a way of understanding computational thinking, as basic form of digital literacy, or as an essential skill for the digital economy.

This section will start by looking at what exactly was meant by the word "computing" in terms of the curriculum, and then look at the arguments for computational thinking', digital literacy, and the digital economy. Finally, there will be a consideration for the arguments for teaching computer programming.

What should be understood was that the anticipation was for a curriculum which had a degree of balance in order to prepare young people for the future. However, almost before the curriculum had been released, it was already being criticised as this quote from a report commissioned by the Labour party (in opposition at the time) states:

We need to support teachers to acquire new subject knowledge and develop their teaching style for the new computing curriculum. At present, CPD is not enough of a priority across education. In addition, there is an appetite from both teachers and industry for more project based, cross curricular learning which embodies and recognises creativity, problem solving, collaboration, entrepreneurship and self-directed learning. However, time for both of these is a major problem. We need to give teachers (and students) the space they need.

(Philbin, 2014, p. *11)*

While later in this thesis, there is a more complete examination of the academic literature surrounding computational thinking, digital literacy, and the digital economy, the following sections on each of these topics will be focused just on the argument regarding these areas made with concerns to the computing curriculum reform.

2.4.1 'Computing': 'I don't Think That Word Means What You Think it Means'

The essence of the shift from ICT to computing was seen to be moving away from a focus on skills and towards a discipline-based principles and ideas—on a way of understanding problems and describing the world (Peyton-Jones, 2009, p. 3). Using the language of a discipline, allowed CAS (specifically) to argue for computing to take its rightful place alongside mathematics and the other sciences (Peyton Jones, 2016, p. 8); no longer would students be *just* learning how to use office-type software, but they would be learning a *discipline* which would prepare them to better understand the world. CS and computing would prepare students for their future needs (Passey, 2015, p. 3). The move towards computing reflected an international change where several countries had begun to introduce elements of computing into schools as either formal or informal learning opportunities (Savage & Csizmadia, 2015, p. 243).

The idea of the focus on computing was that it would create a much more "exciting" subject than that of ICT. CAS (2012) went so far as to make the following statement:

> *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. (Computing at School, 2010,* p. 2).

With all this hype, what exactly made up "Computing". The focus of computing was very much to be on the theory rather than on practice—concepts rather than artefacts (Computing at School, 2010, p. 3):

Computing was primarily stated to be made of 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.

(Computing at School, 2010, p. 3; Peyton-Jones, 2009, p. 4)

Interestingly, while these points do not include any aspect of using specific software, they also do not mention learning programming or coding. What can be concluded is that computing is a discipline that focuses primarily on a theoretical understanding of the digital world, but at the same time, it was expected to be significantly more exciting than learning how to use software.

The key point about computing (as opposed to Computer Science specifically) is that it is to provide students with the insights into ALL of the STEM disciplines, giving them the skills and knowledge that can be applied to solutions in any STEM subject (BCS, 2010, p. 6). Therefore, the promise of computing is that it is by its nature cross curricular, exciting but also theoretical specific, and applicable to any number of disciplines.

2.4.2 Thinking a bit About Computational Thinking

The definition of computational thinking was not made clear in reference to the curriculum. This lack of clarity has continued to cause problems for teachers as computational thinking has become a "buzz word", where on one hand teachers acknowledge the need to teach it, while on the other hand, they have no idea exactly what it is (Woollard, 2018, p. 20).

Like the term "computing", part of the role of computational thinking was to make the subject of computing applicable to any number of subjects and at the same time, be able to include aspects that may not be associated with Computer Science, such as problem solving and creativity, compensating for the removal of many of the creative aspects—a part of the ICT curriculum (Savage & Csizmadia, 2018, p. 137). The promise of computational thinking was that it was a way of thinking about the problem-solving process itself rather than a form of problem-solving (Peyton-Jones, 2009).

Computational thinking is at the heart of computing, which focuses not on things that may appear to be much like ICT but on the contemporary idea of problem solving or even complex problem solving which might not involve programming, or using a computer at all (Passey, 2016, p. 4; Woollard, 2018, p. 15). This aligns with a contemporary style of political thinking which focuses on technical solution in the face of complex problems (Williamson, 2015, p. 53).

While on the other hand, computational thinking was also described as something "teachers of Computer Science have been facilitating [sic] in their students as long as this subject has been taught" (Savage & Csizmadia, 2018 p. 244).

Computational thinking perhaps could best be described as a way of viewing the world where computers have moved into almost all areas of modern life and new ways of viewing the world. Computational thinking promises an insightful way of viewing how information operates in natural and engineered systems (Royal Society, 2012, p. 10).

The implementation of computational thinking is seen as one of the primary successes of the computing curriculum. "The 2014 national curriculum is lauded as inspirational and instrumental in bringing computational thinking to the fore in the education of all learners" (Woollard, 2018, p. 22).

2.4.3 Are You Ready for the…… Digital Economy?

Even in earlier debates about IT/ICT and computing in school, the economy played a central role. In the 1980s, much of the defence of increasing the role of IT in schools was tied to the rise in technical jobs with the prediction that almost every industry and sector would be affected by microelectronics technology. It seemed essential that pupils became computer literate while still at school (Mackay, 1991, p. 4; Webster & Robins, 1991, p. 73). The IT82 campaign claimed that IT would transform every sector of the economy from factory work to pubs, from secretaries to health care professionals (Webster & Robins, 1991, p. 73). Oddly enough, looking back, these predictions seem surprisingly prescient—almost every sector has been transformed by some form of technology and impacted by microchips, which itself seems to be an excellent economic argument for relevant computing education to be taught in schools. In the past, it proved correct that every sector would be affected. However, this does not answer the question of 'what' should be taught.

The Royal Society (2012) report, while making the case for digital literacy highlighted the danger that the lack of enthusiasm which was associated with the ICT curriculum could have detrimental effects on UK plc, reducing the ability of the UK to compete on an international stage (p. 14). The Report goes on to make the 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, p. 27). While there has been a growth in the IT industries with roles such as software engineers, this reflected a tendency across a number of commentators and organisations to glamorise the reality of the discipline of computing in order to build a skills base for the digital sector (Williamson, 2015, p. 50).

Livingston and Hope (2011) highlighted that the Digital Economy will not be just based on small set of technical skills but rather a multidisciplinary approach would be needed and skills such as: team working, and communication and artistic ability would be just as important. What they also found was 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, pp. 24-30). Which may mean that while the computing curriculum would need to give young people the skills, they would need to participate in this sector they would also need to be given a sense of what a career in this sector might entail.

BCS (2010), as the industry body for the IT, estimated that more than half of workers in the UK used IT:

> *Around one million people in the UK are estimated to be employed in a 'computing role' out of the tens of millions who access and use IT to support their job role. A 2001 study found 59% of the UK working population use IT in a professional context*. (p. 7)

So, while the curriculum reform was well under way, there continued to be concern that many young people were missing out on the opportunities available to them in the ever-expanding digital work. The Labour party commissioned the "Digital Skills for tomorrow's world" to consider what skills would be needed for the new economy (Philbin, 2014). This report highlighted that all sectors needed IT abilities:

> *As of August 2012, the digital economy accounted for 14.4% of all companies and 11% of jobs. It's not just the technology sector that needs digital skills but all sectors. Consequently, […] increasingly "every company is a digital company and almost every job is a digital job." (Philbin, 2014,* p. 4)

While there were many opportunities in the digital workplace, these were often pursued by young people who fit a pre-existing stereotype: "the gender imbalance in tech is extremely damaging: it is hardly surprising that we have digital skills shortages given that we are failing to make the most of the talents of almost half of the potential workforce" (Philbin, 2014, p. 10).

One of the goals of the inclusion of computing in the national curriculum was to give every child the knowledge they needed as adults to make "intelligent and informed choices about the digital technology that underpins their world and [that] they are capable of making valuable contributions to our digital society and economy", equipping every child with the basic knowledge and competencies to take their "proper place in a digitally enabled, knowledge based society and economy" (BCS, 2010, p. 5).

While the case for the digital economy was clear, there was a concern that the hype may also have underplayed the downside to a career in the digital economy where jobs often come with a degree of fragility, complexity, and mundanity (Williamson, 2015, p. 49).

2.4.4 Why Everyone Has Got to Learn Digital Literacy

The argument for digital literacy is generally threefold: in the first place, digital literacy is compared to the basic ability of reading and writing (Royal Society, 2012, pp. 6-8); secondly, it is seen as the ability to use basic applications such as the ability to use a standard set of office-type software such as word processors, email and presentations software, the ability to create and edit images, audio and video, and the ability to use a Web browser and Internet search engines (Philbin, 2014 pp. 4-5; Royal Society, 2012, p. 18; Woollard, 2018, p. 20); and finally, digital literacy is seen as the skills needed to become a digital citizen and participant in modern society and even democracy (Royal Society, 2012, p. 28).

While these three stances on digital literacy are generally accepted to be essential for every young person, there is a question as to how digital literacy fundamentally differs from the ICT curriculum as now "basic digital literacy contributes towards all sectors of the economy" (Royal Society, 2012, p. 24). While digital literacy tends to be described as a set of skills rather than a subject in itself (Royal Society, 2012, pp. 86), it is a set of skills that is relatively vague, which currently is seen as involving some level of engagement on the Internet with "the ability to find, evaluate, utilise, share, and create content using information technologies and the Internet" and the essentials skills for young people to become digital citizens (Preston et al., 2018, p. 70). Digital literacy, then, is a term which may also be expanding to include taking advantage of the connectivity of computer networks, engaging in social communication, and exercising control over information—skills that are essential for the everyday lives of a digital citizen (Philbin, 2014 pp 4-5; Woollard, 2018, p. 20). Lack of these skills could preclude an individual from both society and the job market (Philbin, 2014, pp. 4-5).

While there is no question that digital literacy is important, there can be an assumption that young people do not need to be taught how to get on the Internet. This is not the case: these skills need to be explicitly taught. While some young people do pick up some of these skills at home, their knowledge can be patchy (Royal Society, 2012, p. 21). Not only is this a question of filling in a gap, but also an issue of social justice and economic efficiency as there can be large skills and knowledge gaps between those students who use the Internet and those who have never been online—with those from socially disadvantaged backgrounds having the lowest level of ICT use and digital skills (Passey, 2016, p. 8; Philbin, 2014, p. 16).

While the curriculum was criticised for having had many of the aspects related to digital literacy removed, it is worth examining to what extent young people feel prepared to engage and participate in digital society. Therefore, this study has used "digital literacy" as the third theme to investigate with regards to the implementation of the English computing curriculum.

2.4.5 How Important is it to Learn to Code?

The procedure of writing a computer program using code could be classified within any of the three existing themes already examined. It can be seen as one of the essential skills needed for the digital economy (Royal Society, 2012, p. 27), and it is the very 'reading and writing' of computing and, therefore, could be seen as the literacy of computing.

From both CAS and the BCS, there is little question as to the importance of learning to program. While computing is not just programming, programming can be a vehicle through teaching, problem solving, creativity, sequencing, and logic, fostering personal learning and problem-solving skills (BCS, 2010 p. 6; Peyton-Jones, 2009, p. 4).

More importantly, it is argued, programming empowers students to become creators rather than simply consumers of digital content: "This ability unleashes enormous creativity and opens up whole new horizons of possibility" (BCS, 2010, p. 6). While on one hand, coding is argued as the key to creating digital content, it is also like basic algebra—essential for constructing elementary algorithms to encapsulate ideas: "Programming is a way of expressing creativity, of communicating and sharing ideas, just as mathematics is in a different area of discourse. Writing exact instructions is a fundamental skill" (BCS, 2010, p. 6). Woollard (2018, p. 20) proposes that by learning how to program, young people will gain control not only over applications and programs that exist today but also control over technology that has yet to be devised. He also argues that by learning to program, pupils are able to find new uses for computers, where ICT skills allow them to create new documents; by learning to code, pupils can create new behaviours of computers rather than relying on the behaviours provided (Woollard, 2018, p. 20). Programming, when it is more than just writing code, embodies the concept of computational thinking, which is problem solving with Computer Science concepts like abstraction and decomposition (Passey, 2016, p. 4). Williamson (2015, p. 49) goes on to argue that writing code is about conducting the "disciplinary regime" as a way to project the "rules" of Computer Science and computational thinking into the world. It may be perfectly possible to teach (and employ) computational thinking without using a computer—let alone programming—at all (Passey, 2016 p. 4; Woollard, 2018, p. 15) which leads to the essential questions: is learning to program a means to and end or an ends in itself within the computing education? It is already reported that pupils and lecturers find computing a "hard" subject (Passey, 2016, p. 11). So, is including programming making this subject essential, or is it making an already difficult subject more confusing?

While Computer Science can be a vehicle for delivering a wide range of skills from ICT to teamwork, programming can be taught in a way that integrates problem solving and creativity—but only if it is not taught through didactic programming activities which involve copying example programs from a white board (Passey 2015, p. 42).

2.5 Looking Back at Computing Education and Thinking Forward

As seen in previous decades, the success encouraging schools to deliver new technology is an investment. In the 1980s, funding came from multiple government agencies supporting training and equipment. In 2014, the UK government provided £3.5 million, the equivalent of £175 per school. In order to deliver this new curriculum, teachers needed to have access to CPD to acquire subject knowledge and adapt their teaching to the new computing curriculum; however, this has been slow to materialise (Philbin, 2014, p. 11).

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 can be said to have had a lasting legacy for young people, the country, and the UK economy (Woollard, 2018, p. 23). The 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 needs identified prior to its implementation.

While the current curriculum may result in a generation of young people who have been introduced to computational thinking, will they understand how to use technology in their everyday lives? Will they understand how their lives are shaped by technology and that they can use technology in their future lives and careers? The next chapter will review the academic literature as related to the three themes of computational thinking, digital literacy and the digital economy.

Chapter 3: Literature Review and Literature Context: Looking at Digital Literacy, Digital Economy, and Computational Thinking

3.1 Literature Context: An Introduction

As has been demonstrated through the previous chapter, the 2014 English computing curriculum is underpinned by the idea that pupils will be prepared for the digital economy, that they will become digitally literate, and that they will gain skills in computational thinking.

This chapter examines the academic literature and discourse of digital economy, digital literacy, and computational thinking. As all of these topics are fast moving and emerging areas, some grey literature has also been included in this chapter as a valuable source on how these terms are being used in the most up-to-date manner. This chapter will establish a working definition for each term, which can be taken forward within the thesis to question the extent to which young people are gaining the skills and understanding for each area.

3.2 What is the Digital Economy?

The following section explores the concept of "digital economy" as it has developed and been discussed over the last several decades. The term "digital economy" has had a number of definitions over this period as technology has progressed and understandings have developed. This section will consider several different key aspects of the digital economy in order to provide a theoretical context.

This section starts by looking at how the digital economy has been defined previously and how older definitions of the digital economy have lost relevance but have not been updated as technology progressed. This section will also consider a new way of looking at the conception of the digital economy, which divides the digital economy into three distinct periods. These periods will help to outline why and how the skills, tools, and knowledge needed to be successful in the digital economy have also changed and developed. This section will conclude with a working definition of "digital economy" and provide a way of thinking about the digital economy that can be used in a computing educational context.

3.2.1 Defining the Digital Economy

Although the term "digital economy" is used widely, relatively few authors have attempted to establish any sort of working definition for the term: their thinking is reflective of the concepts and ideas evident from the time in which these authors were writing, and their positions reflect the ongoing development of technology at these points.
Given the shortage of academic literature, this section starts by investigating the understanding of the digital economy from recent grey literature.

Digital Economy in Grey Literature.

As the term 'digital economy' has become more widespread, often it is left undefined and vague. For example, in its 2015 report of the UK's digital future, the House of Lords refers to the digital economy by stating, "The whole economy has become digitised. As digital is pervasive across most aspects of our lives, so the 'digital economy' is becoming synonymous with the national economy" (House of Lords, 2015, p. 110).

In a later report on "Growing up with the Internet", although the term "digital economy" is used over 20 times, it is never specified exactly to what it refers (House of Lords, 2017). The difficulty of defining the digital economy is actually addressed by the European Commission in its report on taxing the digital economy: "Defining what constitutes the digital economy has proven problematic, as it is becoming increasingly difficult to separate the two as the use of technologies becomes more commonplace" (Expert Group on

Taxation of the Digital Economy, 2014, p. 4). In an attempt to look at the economic impact of the digital economy, the Department of Business Innovation and Skills in its impact assessment of the 2010 Digital Economy Act also states the following:

> *The digital economy is not so much a sector but rather a significant change in the UK's telecommunication infrastructure in which economic activity, society and cultural way of life become increasingly underpinned by digital and broadband technologies.*
>
> *As yet, there is no agreement on how the digital economy should be defined and measured. Different definitions and ways of measuring have been used giving rise to different estimates of its size. Digital and broadband technologies pervade nearly all sectors of the economy and the fact that they cannot be easily captured using standard industrial classification (SIC) codes makes the task of assessing the importance of the digital economy in terms of its contribution to the GDP and employment extremely difficult. (p. 8)*

The report goes on to focus on a combination of the ICT sectors and the digital content industries, including publishing books, publishing newspapers, publishing software, and renting of office machinery and equipment, including computers, within the digital economy (Department for Business Innovation & Skills, 2010, p. 10). The HM Government "Information Economy Strategy" from 2013, while mentioning the Digital Economy several times and specifically linking the new computing curriculum to the needs of the digital economy, does not define what this might include or what specific skills are needed for the digital economy. Similarly, the House of Commons Science and Technology Committee (2016) refers to the skills for the digital economy, highlighting that the UK has strengths in the fields of Internet of Things, Wearable technologies, Big Data and Data Analytics, 5G and associated wireless technologies, Robotics and Autonomous vehicles, and particularly focuses on the role apprenticeships can play in developing the skills for the digital economy (p. 13). Yet, this report does not present a broad definition of the digital economy that can be used to determine which industries are included or what skills are needed. Similarly, the UK's Digital Economy Act of 2017 looked to tackle many of the regulatory issues of the digital economy without detailing a comprehensive definition, though it implies that the act itself relates to: 1) access to digital services, 2) digital infrastructure, 3) access to online pornography, 4) Intellectual Property, and 5) Digital government services (p. 2).

While this thesis has been funded by the UK's Research Council's Digital Economy Theme (UKRI), rather than focusing on exactly what is meant by the digital economy, UKRI rather outlines four "priority areas" for research which include trust, identity privacy and security, digital business models, the Internet of things for a service economy, and content creation and consumptions ("Digital Economy – EPSRC Website", 2020). These four themes could apply to a wide range of industries, and these themes imply that the digital economy is far reaching and influencing most aspects of UK economy activity. For the UKRI, as the organisation reflected over ten years of research in 2019, the digital is broad and varied:

> *Back in 2009 when asked, "what is the digital economy?" my predecessor, John Hand, responded "it is very broad and varied, and he was right! Digital economy (DE) is about much more than IT, it's about how we interact with the digital world, how we live with it, and how it affects us.* (Baird, 2019)

Considering the difficulty of understanding what is meant by the digital economy in UK-based grey literature, it is useful to turn to the academic literature and consider how the term "digital economy" has developed and changed over time.

Digital Economy in Academic Literature.

Prior to the year 2000, there is little academic literature that refers specifically or attempts to define the digital economy. Literature from this period uses terms including "Knowledge Economy", "New Economy", "Innovation Economy", and "Information Economy" (Oxley et al., 2008, p. 2; Singh, 2004, p. 8), all of which align to the digital economy. These terms are sometimes used interchangeably, while at other points, authors use different terms to distinguish between slightly different phenomena. For example, Brynjolfsson and Kahin (2002) use the term "Information Economy" referring to "the broad, long-term trend toward the expansion of information- and knowledge-based assets and value relative to the tangible assets", and the term "digital economy" refers to "the recent and still largely unrealised transformation of all sectors of the economy by the computer-enabled digitisation of information". Since this point, many "information- and knowledge-based assets" are tied to and reliant on the "computer-enabled digitisation of information". Looking at Brynjolfsson and Kahin's (2002) definition of "digital economy", it would be hard to argue that this is not still in the process of transforming "all sectors of the economy" (p. 2).

Considering this lack of consistency, this thesis identifies five academic definitions of "digital economy" (see Table 1) and then proposes considering "digital economy" through the inclusion of the development of technology, specifically the development of networked-based communication.

It would be hard to imagine that almost any business operating today would not have been transformed by ICT, or one which has not in some way conducted or facilitated some aspect of its operation electronically. Quah's (2003) definition stands out as it refers specifically to the profit (pay-off) generated by a specific line of code (bit-string) or a sequence of '1's and '0's. While this definition feels more specific, it gives little clarity, as it raises questions about pay-off for whom (those who use the algorithm or those who wrote it?). In addition, is Quah (2003) referring to the pay-off generated by the 'bit-string' as an economic asset (such as intellectual property) or as an economic good (which then benefits the users further)? For example, is Microsoft Excel a "pay-off relevant bit-string" (Quah,2003, p. 3) for a small business that uses it to manage its budget more efficiently, or only for Microsoft who owns the intellectual property of the software (Quah, 2003, p. 6)?

Table 1 - Definitions of the Digital Economy:

Reference	**Definition of Digital Economy**
Brynjolfsson and Kahin, 2002, p. 2	The term "information economy" has come to mean the broad, long-term trend toward the expansion of information- and knowledge-based assets and value relative to the tangible assets and products associated with agriculture, mining, and manufacturing. The term "digital economy" refers specifically to the recent and still largely unrealised transformation of all sectors of the economy by the computer-enabled digitisation of information.
Quah, 2003, p. 6	payoff-relevant bit-string
Ayres and Williams, 2004, p. 2	The important role that ICT-enabled products and services have come to play in modern economies gave birth to the idea of the ''digital economy,'' suggesting a transition to a new set of rules for how to succeed.
Singh, 2004, p. 6	The digital economy involves conducting or facilitating economic activities electronically based on the electronic processing, storage, and communication of information, including activities that provide the enabling physical infrastructure and software.
Rayna, 2008, p. 13	The digital economy is based on the digitalisation of previously existing goods and on the development of new purely digital goods.

What all of these definitions have in common is that they are trying to identify the specific subset of economic changes that represent something both new and specifically “digital”. For example, when trying to identify a “specifically digital good”, Quah (2003) uses the term “payoff-relevant bitstring” (p. 6). However, Ayres and Williams (2004) ICT-based definition indicates that wherever any kind of Information Communication Technology has enabled a product or service, it can be considered to be part of the digital economy (p. 2). This definition more than anything indicates how the context within which digital economy research has developed. Ayres and Williams (2004) state that for the most part, people used the Web as a glorified ”yellow pages”, and that the most promising application for the Web would be interactive video on demand (p. 333). Their prediction is that the rate of technological progress will slow down “…as the asymptotes for different components of information technology are approached” (Ayres & Williams, 2004, p. 336), making it easier (and less relevant) to define the digital economy. Thirteen years after the publication of their paper, this slow down does not seem to be occurring, and it could be said rather that things are actually accelerating (Friedman, 2017). Singh (2004) recognises that even at that time, although not all IT and ICT activities involved the Internet, even so the “gap between computer use and Internet use is shrinking, and for many individuals and businesses, using computers or IT automatically means using the internet” (p. 10).

In 2004, the potential for the Internet was being recognised in the academic literature and authors reflecting on the digital economy were in many ways dismissing the impact of non-Internet digital technology (Carlsson, 2004, p. 262). Carlsson (2004) goes so far as to classify the Internet as a general-purpose technology similar to the steam engine and electrification.

Rayna (2008) recognises that there is a realm of digital good which behaves differently to goods (and services) which are rooted in the physical world. Rayna (2008) draws the distinction that a film or piece of music behave (economically) fundamentally different if purchased as a download rather than on a CD. When the product is purely digital, its economic nature is fundamentally transformed (Rayna 2008, 14).

All of these definitions demonstrate the difficulty of trying to predict the impact of new technologies on the economy, whether ICT or the Internet. In the case of Ayres and Williamson (2004) and Carlsson (2004) respectively, it was clear that ICT and the Internet were transforming economic activity but difficult to fully appreciate the extent of the impact.

Approaches to the Digital Economy.

In more recent literature, there remain few definitive definitions of “digital economy”, but authors either rely on previous definitions or tacit acceptance of an understanding of what is being referenced. For example, Crabtree et.al. (2016) look at privacy and big data in the digital economy, exploring the concept of a new kind of economic actor (p. 947). They explore the new demands on individuals as data has become a more and more tradable economic good, but they take for granted that readers understand what is meant by the digital economy. Equally in Runciman’s (2015) essay about the role of the digital economy when it comes to winning or losing political contests, and even with the sub-title “Why progressives need to shape rather than merely exploit the digital economy” (p. 11), there is a tacit acceptance that the concept of digital economy is understood by his readers. In both of these papers, the digital economy is assumed to involve the use (as a minimum) of social media and buying and selling of [big] data. Runciman (2015) uses the terms “new economy”, “digital economy” and even “digital age” interchangeably, and although he does seem to raise questions about the social and political consequence of technological advancement, his use of the term “digital economy” is more of a short hand to refer to the application and use of digital technologies to economic activities. The digital economy as implied by these contemporary authors only loosely fits into Singh's (2004, p. 6) definitions outlined above (see Table 1).

Another way to look at contemporary literature is that the digital economy has become so pervasive and large that it cannot be pinned down to a single area. Rather than pointing at one thing that is or is not the digital economy, rather it may be more productive to look at a range of models within the digital economy. Peña-López (2010) identifies 3 models for the digital economy: The Telecommunications Model, The Conduit and Literacy Models, and The Broadcasting Model (p. 8). Peña-López (2010) is specifically investigating the role government can have when hoping to stimulate digital economy activities. Peña-López (2010) suffers from the speed of change within technology as these models do not leave room for new areas of development such as the areas eluded to by both Crabtree et.al. (2016) and Runciman (2015), such as the "Internet of Things", "big data" and even "automation".

If Carlsson (2004, p. 262) is right that the Internet is a general-purpose technology that could be compared to the steam engine or to electrification, in time, the term "digital economy" may seem as anachronistic as "steam economy" or "electric economy". The use of the term may symbolise a fundamental transition from one thing to another. It is this concept of transition that sits behind a new understanding of digital economy as proposed below.

Developing a New Understanding of "Digital Economy".

None of the definitions considered thus far are dynamic enough to be useful when trying to define or discuss constantly developing technology. Rather than using any of these definitions of the digital economy, this thesis proposes an approach that looks at the phases of the digital economy over time, suggesting a dynamic way of considering the digital economy that takes into consideration changes in technology and leaves room for future stages of the digital economy which may need to be discussed in literature but will show little resemblance to previous definitions of the digital economy.

3.2.2 Defining the Digital Economy in Phases

There have been a number of technological developments (i.e. transistors, personal computers, networked computing, the World Wide Web, the mobile phone, big data, artificial intelligence), specifically in the area of computers and computing, which over time have had an effect on economic activity (Ayres & Williams, 2004; Brynjolfsson & McAfee, 2014; Carlsson, 2004; Friedman, 2017; Hamid & Khalid, 2016; Keen, 2015). These developments have ranged from the first invention of the transistors developed in 1947 (Ayres & Williams, 2004, p. 315) to more recent developments of artificial intelligence and its use in medicine, transportation, and other areas (Brynjolfsson & McAfee, 2014, p. 92). This chapter does not aim to provide a comprehensive timeline of all developments related to the digital economy; rather, selected authors have indicated a number of pivotal points when it comes to how technology has impacted economics. Using these pivotal points as signposts of key changes, it is possible to divide conceptions of the digital economy into three periods.

This thesis presents the digital economy to date in three distinctive periods of time: 1) before 1994; 2) from 1994–2007; and 3) after 2007. By understanding the digital economy like this, it can explain why much of the digital economy literature can seem somewhat contradictory. These three periods focus on the application of new technology rather than the first invention of those technologies.

The Pre-Digital Economy: Before 1994.

The pre-digital economy is when much of the foundation and infrastructure needed for the later stages of the digital economy evolved. This could be said to have started when the US Census Bureau became the first non-military use of computing technology, circa 1951 (Ayres & Williams, 2004, p. 318). With the advent of the desktop computer in the early 1990s, computers slowly became commonplace in businesses and eventually homes.

It is worth noting, the later development of the digital economy in developing countries followed a slightly different trajectory and has been more dependent on the development of 3G/4G mobile technology rather than physical infrastructure (Hamid & Khalid, 2016, p. 274). Prior to 1994, technology had already had a dramatic effect on economic activity, but this impact was limited to increased efficiency rather than on a shift in the paradigm of how business was conducted. For example, these early uses were things like replacing paper filing systems with digitised databases and replacing filing clerks with computers (Ayers & Williams, 2004, p. 319). This pre-digital economy is the period prior to consumers and businesses having widespread access to digital *networks*, but where they may already have access to digital *technology*, and when major investment is being made in physical infrastructure, education, and R&D.

Digital Economy 1.0: Console Based Digital Economy 1994 – 2007.

After the initial pre-digital economy phase, this thesis uses a number system starting with 1.0, 2.0, etc. for the subsequent phases of the digital economy. This numbering system suggests that these periods could be further subdivided, can be continuous, and indicates that each of these phases builds on the technology of previous periods. This numbering also reflects the numbering of the phases of the Web (1.0, 2.0, 3.0). The digital economy 1.0 runs from 1994 until 2007 when the way that consumers accessed the Internet and digital content became dramatically transformed.

Circa 1994, a number of key companies were founded, including the online retailer Amazon, the first widely used search engine Yahoo, and the first Web browser Netscape (Keen, 2015, pp. 688-723). These companies represent what is often referred to as “Web 1.0” (Keen, 2015, p. 860). In 1994, the digital economy was replacing or supplementing then current markets (making manufacturing more efficient or making storing large amounts of data less costly). By the time access to the Internet became widely and easily available to all, the nature of the economy began to fundamentally change (Carlsson, 2004, p. 262). The Internet browser Netscape made it possible for consumers and businesses to access information from around the world, search engines such as Yahoo made it possible to search this vast amount of data, and the online retailer Amazon made it possible to make purchases (initially for only books) over the Internet. Carlsson (2004) highlights that it was only really access to the Internet that truly transformed the digital economy:

> *So what is really new in the New (Digital) Economy? In a nutshell: the Internet, a new level and form of connectivity among multiple heterogeneous ideas and actors, giving rise to a vast range of new combinations.* (p. 262)

The digital economy, as referred to by contemporary authors writing about technology such as Keen (2015), Doctorow (2014), or Lanier (2010, 2013), doesn’t resemble the pre-digital economy period and seems to take for granted the changes that were new in 1994. Ayres and Williams (2004) also identify the 1990s onward as the beginning of the integration of computing technology and communications technology, enabling the companies which began in 1994 (p. 322).

The digital economy 1.0 was fundamentally about using digital technologies to facilitate the more efficient running of the exchange of goods and services, using the faster and more efficient transfer of information to increase efficiency within existing markets. What was new within digital economy 1.0 was that information could be moved extremely quickly compared to previously. Although new technologies created new markets (such as selling software), the way these goods and services fitted into traditional business models was unclear (Rayna, 2008, p. 13). This was not a new form of economy but more of a digital version of the traditional economy.

Midway through the digital economy 1.0, in 2000, the US stock market crashed, which was seen as connected to over-confidence in this first generation of Internet companies (Keen, 2015, p. 723). After the crash of 2000, new business models were developed that relied on users producing content and interacting with one another. This post 2000 period is sometimes referred to as "Web 2.0" and is associated with the rise of social media platforms such as Facebook, founded in 2004 (Keen, 2015, p. 1136)[1].

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[1] *This history of the World Wide Web has been classified as Web 1.0, Web 2.0, and Web 3.0, (Allen, 2012, p. 261).*

Web 1.0 and Web 2.0

The term Web 1.0 is usually used in contrast to Web 2.0 which is when the more interactive content became user generated: Web 1.0 was static, Web 2.0 is dynamic and interactive ("What is Web 2.0?", 2017). Web 1.0 to Web 2.0 is also seen as a shift from software to platforms ("What is Web 2.0?", 2009). Murugesan (2007) asserts, "Web 2.0 is both a usage and technology paradigm. It's a collection of technologies, business strategies and social trends." Web 2.0 was a way to invite a broader range of users to use it as a medium to have a voice. "Web 2.0 is mostly a social revolution in the use of Web technologies, a paradigm shift from the Web as a publishing medium" (Lassila & Hendler, 2007, p. 90).

Web 3.0 and Possibly Beyond

Research in to Web 3.0 started as early as the 1980s (Lassila & Hendler, 2007, p. 90). The general shorthand definition of Web 3.0 is "the Semantic Web"—the term "semantic" referring to the ability of computer technology to understand or interpret natural language (Berners-Lee & Hendler, 2001, p. 1023). This idea of machine interpretation of meaning of natural languages is strongly linked to research into artificial intelligence (Lassila & Hendler, 2007, p. 90). Web 3.0 relies heavily of the foundation of the earlier versions of the web, in particular the vast number of social interactions made possible through Web 2.0 (Morris, 2011, p. 43). Beyond Web 3.0 very likely will involve the integration of the physical world into the Web (Lassila & Handler, 2007, p. 92). Something beyond Web 3.0 could be imagined once the number of devices (such as the internet of things) connected to the internet exceeds a critical mass.

At the same time as the Internet made its way into every office, home, and school, a new shift also happened. This can be described as the shift from when the digital economy created value through efficiency to when the digital economy created value through communication, information, and technology in themselves:

> *Interpreted in this way, the New or Digital Economy is about dynamics, not static efficiency. It is more about new activities and products than about higher productivity. What is really new in the New Economy is the proliferation of the use of the Internet, a new level and form of connectivity among multiple heterogeneous ideas and actors, giving rise to a vast new range of combinations* (Carlsson, 2004, p. 245).

The distinction between consumers and producers began to blur. Non-market transactions, which are only the movement of information from one place to another (such as a Web search), now created real economic value. This type of transition was not only vastly different from the way value had been created in the past but was also very difficult to measure and, therefore, was not often studied (Brynjolfsson & Saunders, 2010, p. xiv).

Digital Economy 2.0: The Mobile Digital Economy.

The next stage of the digital economy is what can be referred to as "digital economy 2.0" and began in 2007 with a number of reasons why this can be identified as a second major shift. The journalist Thomas Friedman (2017) identifies 2007 as the pivotal point when a number of events occurred in terms of technology, including: the launch of the Apple iPhone, the Android operating system, the launch of Amazon's Kindle, and the launch of a company called Hadoop, which was one of the first "Big-Data" analytic companies (p. 19). In Friedman's (2017) view, these companies fundamentally changed the perspective of the impact of the technology. For example, the launch of the iPhone and other brands of 'smart' phones meant that the Internet was no longer something that had to be accessed through a console with a screen and keyboard, but rather could be accessed from anywhere with a mobile phone connection. The iPhone was not the first Internet-capable mobile ‘smartphone’ since the Blackberry system had been available for several years beforehand, but at that stage the Blackberry had remained a product used by more elite commercial users, rather than the general public. The Kindle meant that the e-book was no longer a poor alternative to a real text, but that a library of books could be taken with the user and read anywhere. More importantly, mobile Web technology meant that (when combined with big-data analytics) the Internet was not simply about connecting people and moving information between them, but also about connecting devices that transmit and receive large amounts of data. The wide use of both the iPhone and the Android operating system resulted in the development of online services where software applications could be purchased and downloaded through application marketplaces, with digital ‘apps’ being sold in a fashion that would have been impossible previously.

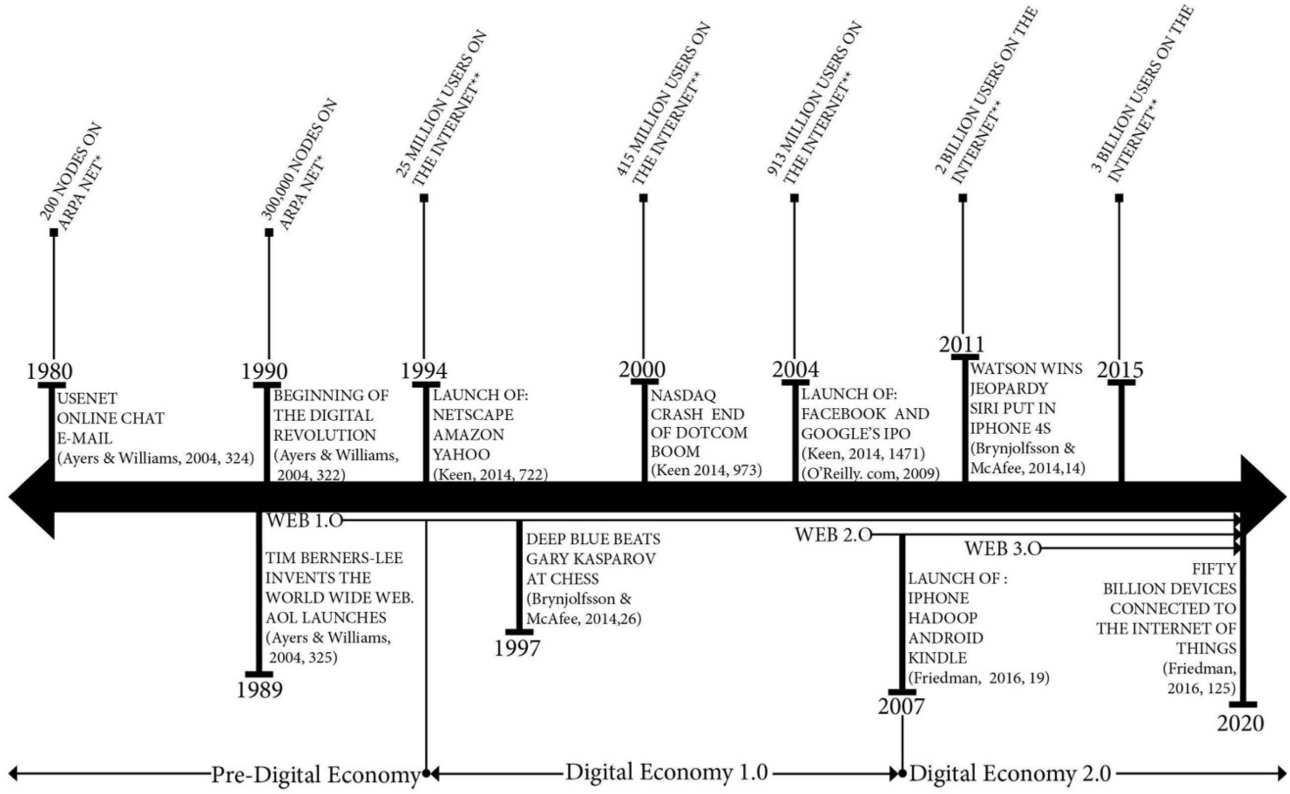

Figure 1: Timeline of the Three Phases of the Digital Economy

*http://www.americanscientist.org/issues/pub/2000/5/the-nerds-have-won/3. Viewed 29/4/2017
**http://www.internetlivestats.com/internet-users/. Viewed 29/4/2017. Rounded to the nearest million/billion

Three Phases of the Digital Economy.

Figure 1 is an indicative timeline of the digital economy, and the terms “pre-digital economy”, “digital economy 1.0”, and “digital economy 2.0” are imposed classifications to help refer to the perspective of literature and how the view of the digital economy has changed over time. The points at 1994 and 2007 are not to say that significant technological advancements did not occur before these points. Rather, these points indicate symbolic commercial or economic events which demonstrate the technological advancements being brought to a wider consumer base.

The underlying purpose of using these three terms is not to undermine or invalidate any literature concerning the digital economy, but rather to make it easier to understand this literature within the context it was written. The field of the digital economy suffers from being both a young field as an academic discourse and a fast-moving field as technology advances. This timeline makes it possible to provide a brief overview of the most relevant literature while at the same time not dwelling on literature which was written within in a different period of the digital economy.

It would be possible to make predictions about what will herald the end of "digital economy 2.0." For example, this could be the widespread commercial use of artificial intelligence or virtual reality, or the wide spread use of Internet of Things (IoT) technology. However, while this shift is possibly already occurring, this thesis will not make predictions about what will drive the digital economy beyond 2.0.

3.2.3 The Digital Economy and Education

When it comes to computing education, understanding the phases of the digital economy can be very useful, as it allows the question to be asked "what sort of digital economy are young people being prepared for?" Computing education in the 1980s prepared young people for the pre-digital economy—when computing systems were creating efficiencies within businesses, but these computers were not yet networked in a coherent way, and the overall economic structure was not disrupted. Young people learned about how to program computers and work with computers but did not learn much about using software or networking.

Digital Economy 1.0.

During this period, the Internet changed how people communicated and how business was conducted, although access to the Internet was widespread and Internet-enabled companies were growing. Internet access was limited to a human being sitting at a console (usually at a desk). The products and services of this period were primarily digitised versions of older products and services. In the 1998 ICT curriculum, young people learned about using software, using computers as a business tool but learned little about using the Internet or programming. These skills reflected the efficiencies of the pre-digital economy without leveraging the power of digital networks and did little to prepare young people to take full advantage of the Internet, World Wide Web, or connected businesses.

Digital Economy 2.0.

This is the period of digital economy when access to the Internet was possible almost anywhere and anytime by a human being on a mobile device. New kinds of products have begun to develop, and most aspects of business and sectors are in some way reliant on a digital device. Once the digital economy 2.0 began, it is understandable that young people found what they were then learning in ICT hard to engage in as it reflected a state of technology very remote from the world they knew. This is not to say an ICT approach may not still be required, but the skills, technologies, and assumptions about the future needed to be updated to reflect the digital economy 2.0.

For this thesis, digital economy will generally refer to the process of digitisation and the growth of the importance of the Internet and World Wide Web to business that is characteristic of the Digital economy 2.0. If discussing young people "working in the digital economy", then this would refer to young people working in a sector that could not exist without this digitisation and Internet access, such as software developer, Web developer, network system administrator, or YouTube star. While other job roles such as nurse, veterinarian, or beautician may rely on the digital economy 1.0 to operate, they are not part of the digital economy 2.0.

This chapter now moves on to consider the second key theme of digital literacy.

3.3 What Does it Mean to be Digitally Literate?

The Department for Education (2013), in the preface for the computing curriculum, states that digital literacy is primarily a set of skills that students will be “able to use, and express themselves and develop their ideas through, information and communication technology at a level suitable for the future workplace and as active participants in a digital world”. This conception of digital literacy is focused on specific skills which are specifically tied to the future workplace and tied to participating in a digital world.

In the academic literature, there is great concern about how (if at all) the concepts of digital literacy relate to literacy in general:

> *Digital literacy is usually conceived of as a combination of technical-procedural, cognitive and emotional social skills. For instance, using a computer program is conceived as involving procedural skills (e.g., handling files and editing visuals), as well as cognitive skills (e.g., the ability to intuitively decipher or “read” visual messages embedded in graphic user interfaces). In the same way, data retrieval on the Internet is conceived of as a combination of procedural skills (working with search engines) and of cognitive skills (evaluating data, sorting out false and biased data, and distinguishing between relevant and irrelevant data). Effective communication in chat rooms is conceived of as requiring the utilization of certain social and emotional skills. With the increasing exposure to digital working and learning environments, digital literacy has been conceived as a “survival skill,” a key that helps users execute complex digital tasks effectively*. (Aviram & Eshet-Alkalai, 2006, p. 1)

However, other authors find that the concept of digital literacy can be hard to define because the technologies the concept is tied to are themselves developing (Chase & Laufenberg, 2011, p. 535). More recently, Belshaw (2012, p. 221) highlights the inherent difficulties in formulating a definitive definition of digital literacy (p. 221).

The widespread use of the term "digital literacy" began in 1997 with a publication by Paul Gilster (1997) where digital literacy was linked to the skills needed to use the Internet (Bawden, 2008, p. 18).

The following sections begin by examining some of the theoretical roots of digital literacy, looking at a number of authors (Aviram & Eshet-Alkalai, 2006; Bawden, 2008, 2001; Buckingham, 2008; Eshet-Alkalai, 2006; Aviram) who have grappled with finding a definition of digital literacy within a number of different contexts.

3.3.1 Theoretical Approaches to Digital Literacy

As a theoretical concept, digital literacy can be looked at from three approaches: 1) How has the concept developed in literature since its first uses in 1997? 2) What considerations need to be made when teaching digital literacy? 3) As several authors refer to digital literacy as a "survival skills", what sort of skill might this be and what are these specific skills that make up the "survival skills"?

The Development of the Idea of Digital Literacy.

The term "digital literacy" is strongly related to a number of other "literacies" of the 21st century: these include information literacy, computer literacy, network literacy and Internet literacy (Bawden, 2001, p. 1; 2008, p. 17; Koltay, 2011, p. 213). While some of these concepts have been in use since the early '80s, the conception of digital literacy itself was not in widespread use until the late ‘90s and has been strongly aligned to how information could be presented and communicated by the Internet (Bawden, 2008, p. 18).

The term “computer literacy” focuses mostly on skills and an understanding of specific tools. Computer literacy is related to being able to use the computer and specific software tools to extend traditional literacy but also understanding enough of the technology to be able to fix a problem independently should something go wrong (Bawden, 2001, p. 7; Koltay, 2011, p. 215).

Conversely, when first used, the phrase “digital literacy” essentially meant the ability to access and understand information using computers: “Digital literacy is the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers” (Glister, 1997, p. 1). This is to say, “digital literacy” is about “mastering skills not keystrokes” (Bawden, 2008, p. 18).

Lanham (1995) argues that the nature of information changes in the digital age, and to be able to call oneself literate in this digital age, one must be able to understand and compose information in a wide variety of ways. What Lanham (1995) says is that traditional literacy drew a distinction between an oral culture and a written one and that the development of digital information is a striking shift (Lanham, 1995, online). Part of developing an understanding of digital literacy is that it is not just about having a set of skills in the way that literacy per se can be understood as strictly the ability to read and write, but rather digital literacy should be seen as wider set of skills, understandings, and attitudes towards information and technology (Bawden, 2001, p. 25).

If the nature of digital media is that information comes simultaneously from a wider range of sources, the skill of critical thinking is seen as intrinsic to digital literacy as it is needed to be able to decipher this information (Bawden, 2008, p. 24). Bawden also makes the distinction between “content” (formally published materials) and “communication” (informal messages): “the former is represented by books, journal articles, etc., the latter by letters, diary entries, etc. Distinct entities in printed media, they overlap in the digital realm through such things as blogs and wikis, undeniably communication, but with the potential to generate content” (p. 27).

Rather than the distinction between types of media being overtly apparent, in the digital age, the user must use critical thinking skills to determine the nature of the media they consume. The development of the term “digital literacy” represents the two changes in literacy. First is the changing nature of information—information rather than being presented in a strictly text-based system, now comes at the user in a multimedia digital format (Lanham, 1995). Second, digital literacy also represents a change in what it means to be a literate person, and, therefore, also designates a moral framework and a set of attitudes that sit alongside skills knowledge (Bawden, 2008, p. 29; Buckingham, 2008, p. 74). Digital literacy has become the underpinning ability that gives students and teachers the ability to succeed in a digital environment (Martin, 2005, p. 131).

Thinking about how information is presented in a digital environment and the skills needed to process this information, Eshet-Alkalai (2004) presents five cognitive digital literacy skills which suggest they could be used to develop a framework for future research into digital literacy:

- Photo-Visual: Learning to read from visuals
- Reproduction Literacy: The Art of Creative Duplication
- Branching literacy: Hypermedia and thinking or multiple-domain thinking
- Information Literacy: The Art of Always Questioning Information
- Socio- Emotional Literacy: Being able to work with other online. (p. 103)

The purpose of this framework is not to set out a strict definition of digital literacy, but rather to seek a way for scholars to use a shared language that further explores what is actually encompassed by digital literacy (Eshet-Alkalai, 2004, p. 103).

In contemporary literature, much of the theoretical debate has died down, but there is an acceptance that the term "digital literacy" carriers with it a degree of plasticity depending on context. Hall et al. (2014), in their study of digital literacy among teachers, choose to ensure that the definition they rely on is built up as a composite from literature:

> *Digital Literacy refers to the skills, attitudes and knowledge required by educators to support learning in a digitally-rich world. To be digitally literate, educators must be able to utilise technology to enhance and transform classroom practices, and to enrich their own professional development and identity. The digitally literate educator will be able to think critically about why, how and when technology supplements learning and teaching. (*p. 5)

In this definition, there are a number of key themes that are consistent from the earlier work in the area, specifically that digital literacy is a mixture of the technical skills required for a 'digitally-rich' world alongside the critical thinking skills needed to reflect upon this practice.

Bhatt et al. (2015) find that for students, digital literacy is inherently multi-modal, meaning that it involves switching between devices, sources, and social modes in quick succession (Bhatt et.al. 2015, p. 481). They state that not only is it the nature of how culture is communicated that is changing, but it is also the very nature of culture is changing due to digital media (Bhatt et al. 2015, p. 481).

Teaching Digital and Media Literacy in Education.

Buckingham makes a comparison between digital literacy and media literacy (Buckingham, 2008, p. 73): both impact how education is delivered, while raising questions about what concepts and skills should be delivered. Equally, in the case of general and digital media, students experience them in education while also consuming them at home. Digital media in particular is a significant part of how young people engage with the world outside of school and education:

> *The internet, computer games, digital video, mobile phones and other contemporary technologies provide new ways of mediating and representing the world and of communicating. Outside school, children are engaging with these media, not as technologies but as cultural forms. If educators wish to use these media in schools, they cannot afford to neglect these experiences: on the contrary, they need to provide students with means of understanding them. (Buckingham, 2008,* p. *74)*

While digital literacy may be a core skill in the digital age (Aviram & Eshet-Alkalai, 2006, p. 1; Eshet-Alkalai, 2004, p. 94), Buckingham raises the question of how digital literacy differs from media literacy. Is digital literacy being used as an updated version of media literacy, or is in fact something fundamentally different?

Digital literacy is seen as a combination of what Aviram and Eshet-Akalai (2006) call "technical-procedural, cognitive and emotional social skills" (p. 1)—how one uses technological tools, how one thinks about those tools, and how one uses those tools to connect with other individuals specifically on an emotional level (Aviram & Eshet-Akalai, 2006, p. 94). This is reflected in Ng's Venn diagram of what constitutes digital literacy (see Figure 2, section 3.3.2) (Ng, 2012, p. 1067).

While media education has taken on a critical approach to literacy, Buckingham (2008) argues that this approach has not gone far enough to encompass digital media (p. 78). One of the main areas that is substantially different between media literacy and digital literacy is that within digital media (and specifically Web 2.0 technologies), individuals are no longer just receivers of information but also producers of content (Koltay, 2011, p. 218).

With media literacy, it is essential to know how to receive information from a wide range of sources; in essence, from a literacy point of view, this is not significantly different to the way that information was received from previous forms of media (a computer game was not drastically different from a television program) (Buckingham, 2008, p. 73). Digital literacy is different from media literacy in how it requires students to draw from a wide range of sources almost simultaneously judging and evaluating these sources of information in real time, while communicating and engaging in a wide range of environments (Bhatt et.al. 2015 p. 478; Chase & Laufenberg, 2011, p. 536).

When discussing digital literacy in the context of the computing curriculum, the Royal Society (2012) define digital literacy as "the general ability to use computers" (p. 5) and present a more comprehensive definition later in the report:

> *Digital literacy should be understood to mean the basic skill or ability to use a computer confidently, safely and effectively, including: the ability to use office software such as word processors, email and presentation software, the ability to create and edit images, audio and video, and the ability to use a web browser and internet search engines. These are the skills that teachers of other subjects at secondary school should be able to assume that their pupils have, as an analogue of being able to read and write. (*p. 17)

In the same way, as students immersed in a media landscape need the skills of media literacy, students immersed in a digital media landscape need to be given the conceptual frame to navigate this new environment (Buckingham, 2008, p. 88).

Essential Survival Skills.

Understanding digital literacy as something more than just basic competence means that teaching digital literacy is far more complex than just ensuring the pupils can use a keyboard or find a Web site:

> *Gilster, as do other authors, suggests this new literacy has to be seen as an essential life skill – 'becoming as necessary as a driver's licence' – or even (presumably metaphorically) as a 'survival skill'. This, for Gilster, primarily reflects the significance of the Internet, which, if it will not overwhelm each person's life overnight 'will change it, subtly, continually, and with irresistible force'.* (Glister, 1997, as cited in Bawden, 2001, p. 23)

Eshet-Alkalai (2004) also uses the term "survival skill" but recognises that the term "digital literacy" is not used consistently in literature, so that it is difficult to fully define what the scope of this survival skill is composed of—whether it is a set of competencies or if it is more conceptually driven (p. 102).

Whether or not digital literacy is a "survival skill", it could also be seen as an essential skill for education more broadly. Chase and Laufenberg (2011) acknowledge that educators' understanding of digital literacy must be constantly developing – as the educators' understanding of the future is also constantly developing (p. 537). Chase and Laufenberg (2011) then propose that the essence of digital literacy is where technology is leveraged effectively for more long-standing values of education of inquiry, research, collaboration presentation, and reflection. This stance is also reflected in the Royal Society report (2012) that digital literacy should be seen as analogous to being able to read and write (p. 17), also highlighting that these skills need to be taught (p. 21).

The conundrum facing educators and students is that the term “digital literacy” is presented as the essential skills for navigating a digital environment. But as the technology that makes up this landscape is developing, does the understanding of digital literacy also need to be continually developing, or are there key concepts which continue to underpin it?

3.3.2 A Practical Approach to Exploring Digital Literacy

As well as a theoretical approach to digital literacy, there have also been a number of practical studies which have examined the value of digital literacy as a skill to both young people and adults. The first set of papers look at digital literacy among young people who have grown up with digital technology (referred to as “digital natives”). The second set of papers are studies which have been conducted in the UK and, therefore, are more directly relevant to how digital literacy has been understood in terms of the English computing curriculum. These papers taken as whole add to an understanding of digital literacy and either aim explicitly as a set of skills or as a cognitive understanding of digital tools.

Teaching Digital Literacy to Digital Natives.

Eshet-Alkali and Amichai-Hamburger’s study examines the performance of users of different ages in the completion of tasks that required utilisation of different types of digital literacy (Eshet-Alkali & Amichai-Hamburger, 2004, p. 423), drawing on the conceptual model of digital literacy (p. 94). Eshet-Alkali and Amichai-Hamburger (2004) looked at the digital literacy capability in three groups each of twenty members: one of high school students, one of third year college students, and finally adults between the ages of 30 and 40 (p. 423). They have three findings of note: first, that the younger participants had better technical skills and were able to more quickly navigate digital environments that used a mix of images and text; their second observation is that for when asked to produce and reproduce meaningful essays based on digital information, the older participants scored much better indicating that younger pupils need to develop cognitive skills rather just technical skills to be able to use digital information; the third finding was that younger pupils struggled to appropriately judge information with critical thinking skills. Eshet-Alkali and Amichai-Hamburger strongly question the idea that young generations automatically are more digitally literate by default. They suggest that technical competence was being taught to the detriment of more cognitive approach which would equip pupils to understand and use information (Eshet-Alkali & Amichai-Hamburger, 2004, pp. 426-427).

The examination of digital literacy among individuals more familiar with computer technology is also taken up both by Ng (2012) looking at pupils in Australia and Gui and Argentin (2011) in Italy. Ng (2011) specifically looked at digital literacy among “digital natives” using Prensky’s (Presnky, 2001 as cited by Ng 2012, p 1065) definition of “digital native” as anyone born after 1980 (Ng, 2012, p. 1065). Gui and Argentin (2011) use the term “internet native”, although they do not define this term within the paper. Their sample is entirely third-year high school students (p. 964); it can be presumed that individuals in the sample had a degree of awareness of the Internet from an early age.

Ng (2012) bases the research on the conceptual framework which consists of three over lapping areas labelled as cognitive, technical, and social-emotional (Figure 2).

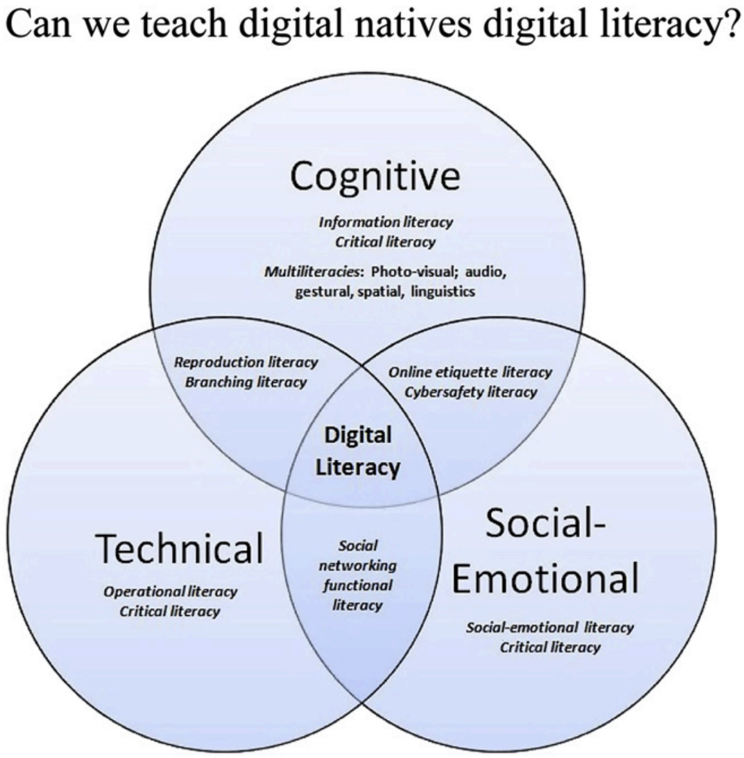

Figure 2: Digital Literacy Framework (Ng, 2012, p. 1067)

Ng (2012) comments that most previous definitions of digital literacy focus on the ability to create meaning and communicate effectively through digital tools, but proposes the above framework includes more depth (Ng, 2012, p. 1067). Ng's (2012) main finding is that "digital natives" are more comfortable using technology as they have had more opportunities to engage with technologies than their pre-1980s counterparts; however, there is still a role of educators to introduce students to digital technologies and new ways of using them in formal settings (p. 1078).

Gui and Argentin (2011) looked at digital divides between individuals from different backgrounds. They found that the educational background of pupils' parents had a strong effect on the operational competence, but that the pupils' evaluation skills of digital information, regardless of parental background, was generally poor (p. 976-977).

What all three of these studies demonstrate is that students and pupils with more experience using specific technologies have an advantage when operating those technologies.

Regardless of the students' ability to use technology or their background, all students were lacking "evaluation" and "critical literacy" skills for digital literacy. Students need to be explicitly taught how to understand, evaluate, and interpret information from digital sources (Eshet-Alkali & Amichai-Hamburger, 2004, pp. 426-427; Gui & Argentin, 2011 p. 977; Ng, 2012, p. 1078).

Recent UK-Based Studies Looking at Digital Literacy.

The following three studies have all looked at digital literacy in the UK. Two of these studies, Hall et al. (2014) and Gruszczynska and Pountney (2013), specifically report on projects which sought to develop digital literacy skills among teachers. In contrast, Bhatt et al. (2015) used digital ethnography to develop an understanding of digital literacy as practiced by young people. Hall et al. (2014) and Gruszczynska and Pountney (2013) described projects that were developed with the changes in the computing curriculum in mind.

Hall et al. describe a project called DigiLit, a project in Leicester to develop digital literacy in secondary school teachers. The authors observe that one of the key questions with the replacement of ICT with computing in the English National Curriculum was that it redefined what it meant to be a competent teacher and raised questions as to whether or not educators had the "the necessary skills, practices and knowledge to support learners as they develop their own digital literacy" (Hall et al., 2014, p. 3). The authors observe that despite a growing interest in digital literacy, there is little guidance for teachers as how digital literacy translates into classroom practice, particularly in light of the fact that there is no consistent definition of "digital literacy" (Hall et al., 2014, p. 3). Through their own review of the literature, they felt that the most mentioned aspects of digital literacy were critical thinking and evaluation (Hall et al., 2014, p. 8). In order to develop digital literacy in educators, the DigiLit project developed the below definition of digital literacy:

> *Digital Literacy refers to the skills, attitudes and knowledge required by educators to support learning in a digitally-rich world. To be digitally literate, educators must be able to utilise technology to enhance and transform classroom practices, and to enrich their own professional development and identity. The digitally literate educator will be able to think critically about why, how and when technology supplements learning and teaching.* (Hall et al., 2014, p. 8)

This is a workable definition in the context of the developing digital literacy skills in teachers and educators, but it doesn't provide clarity as to what digital literacy might look like for pupils (nor does the project set out to do this). The DigiLit project developed a framework for teachers to self-evaluate their own digital literacy in order to develop their teaching practice. The framework consists of four stages of digital literacy:

> *(1) Entry*
>
> *Staff who fall at this level are unlikely to have had many opportunities to experiment or engage with technology in the school context. Whilst they may have some experience of using technology for personal uses, this practice has not crossed over into the professional domain.*
>
> *(2) Core*
>
> *At the Core level, a member of staff can make use of common school technologies and resources and understands how these might be used to support learning and teaching.*

(3) Developer

At the Developer level, the educator has the skills to make use of a range of tools, including the advanced features of commonly available technologies. They understand how their learners and peers use technology socially and ethically.

(4) Pioneer

The Pioneer has integrated ICT use fully into her/his teaching practice. S/he is confident in her/his skills and knows how to apply them in the classroom to create beneficial learning experiences. Pioneers actively engage in CPD outside the local school environment. They reflect on their practice, sharing this with others in a collegial manner, and can provide high quality training."

(Hall et al. 2014, p. 12)

Gruszczynska and Pountney (2013) describe a project called "Digital Futures in Teacher Education" (DeFT). The focus of this project was to explore the possibility of the use of open-source education resources (OER) in UK schools, and also identify "ways in which current digital literacy frameworks do not fully account for digital practices in schools and teacher education" (Gruszczynska & Pountney, 2013, p. 25). Gruszczynska and Pountney explore digital literacy through interviews with current primary and secondary school teachers, PGCE students, and education lecturers (p. 26). They acknowledge the shift of the English National Curriculum from ICT to computing. In 2013, there was renewed interest in digital literacy, but there was little consensus of what would constitute the new curriculum. Within this context, Gruszczynska and Pountney use a definition of digital literacy which is rooted in context and practice:

"The project, therefore, considers [digital literacy] to be a blend of ICT, media and information skills and knowledge situated within a number of different contexts including academic practice." (Gruszczynska & Pountney, 2013, p. 28)

Teachers on the whole found the term "digital literacy" problematic, as it could mean more of a focus on a set of skills and less on purposeful use of technology. The term reduced using technology operation rather than application, and it limited the possibility of incorporating creativity (Gruszczynska & Pountney, 2013, p. 28). The teachers themselves felt unempowered by the term "digital literacy" as they felt it highlighted the contrast in skills between themselves and their pupils (Gruszczynska & Pountney, 2013, p. 29). Gruszczynska and Pountney found that the recurring conceptualisation by teachers and PGCE students was of digital literacy as a set of technical competencies (Gruszczynska & Pountney, 2013 p.29). What Gruszczynska and Pountney describe is that, although some current and future teachers see the potential of digital literacy being taught in classrooms, there are several barriers to this (2013, p. 30-33):

1) **Barrier of Access:** Teachers found that school networks and ICT resources blocked them from accessing social media and other Web 2.0 services which prevented them from embedding digital literacy practice in their teaching practice.
2) **Barrier of Time:** The teachers found that they were very much teaching to the requirements of tests and central governments and pointed out that if something was not going to be explicitly on the test, it was hard to devote time to it.

3) **Barrier of Confidence**: the teachers themselves felt like they were struggling to "keep up" with the pupils—even PGCE students on placement who were only approximately five years older than the secondary pupils they were teaching. The teachers felt their experience of technology was drastically different from the pupils.

Gruszczynska and Pountney highlight that whatever the theoretical stance on digital literacy, the teachers' own understanding of digital literacy is informing the teaching practice.

Bhatt et al. (2015) provide a further contrast as they examine digital literacy through digital ethnographic observation of a pupil's behaviour. They describe an observation of a student working on her level 3 certificate in childcare as she completes an assignment in class. What emerges is a complex interplay of digital literacy practices (Bhatt et al. 2015, 477-478). Bhatt et al. (2015) observe that an understanding of digital literacy cannot draw directly on previous understandings of "literacy" in general but needs to be seen as something new, including a wider range of activity than previously known.

> *"Digital literacies are therefore inherently multimodal, and this expands the researcher's province of interest and analytical lens to include not just the mediating text and spoken meanings but also the wider context in which the literacy activity is taking place. In a classroom context, there can be a variety of static and portable devices being used, such as desktop computers, laptops, tablets, and other devices which offer a wider range of mobility and modes." (p. 481)*

This conception of digital literacy, again, contrasts with either the critical thinking-based understanding of Hall et al. or the competencies-based understanding of Gruszczynska and Pountney (2013). For Bhatt et al. (2015), digital literacy is practice- and context-based—

where pupils navigate between texts and devices in a multimodal multidisciplinary practice. An impact of this research for teaching practice is the need to reflect the way in which pupils need to learn to navigate between devices, sources, and modalities to develop skills in digital literacy.

3.3.3 Digital Literacy and Education

The English Computing Curriculum places digital literacy as a key aspect of what people should learn as part of computing in school, such that rather than just being able to use Information and Communication Technology (ICT), pupils would be enabled to be "digitally literate".

The Royal Society's report, "Shut Down or Restart" (2012), explicitly states that digital literacy should underpin the teaching of computing in the UK as a fundamental skill. From the most recent studies conducted, it seems that beyond legislation there is an urgent need to ensure a consensus of digital literacy and development of teachers' confidence is met.

As has been presented in this section, digital literacy is about having the skills to be successful in a digital environment (Martin, 2005, p.131), and is a broad set of skills, understanding, and attitudes towards information and technology (Bawden, 2001, p. 25).

Digital literacy can be seen as an overlap of three areas: 1) using the technology at hand; 2) being able to understand and evaluate the various ways that information is presented in a digital environment; and 3) the social and emotional demands of interacting with other people in a digital environment. Aviram and Eshet-Akalai (2006, p. 94) refer to these three aspects as "Technical-procedural, cognitive and emotional social skills" (p. 94), while Ng (2012, p. 1067) calls the three areas "Cognitive, technical, and social-emotional" (p. 1067) and further reiterates that 'critical literacy' (i.e. critical thinking skills) are central to digital literacy.

This thesis builds on this threefold understanding of digital literacy, bringing together the models of Ng (2012) and Aviram and Eshet-Akalai (2006), and highlighting that digital literacy goes beyond technical skills and is about having the skills to understand digital media (cognitive digital literacy) and making connections in a digital world (social/emotional digital literacy).

3.4 Computational Thinking: Thinking About Computers, Thinking Like Computers, and Thinking with Computers.

Over the past decade, within the field of computing education, “computational thinking” has become one of the consensus terms that is at the centre of how we teach computing (Waite, 2017, p. 16).

Denning (2017) argues that the term, and more importantly the concept goes back at least to 1960 but possibly even back to 1945; the current debate surrounding computational thinking starts in 2006 when Wing (2006) published her article entitled “Computational Thinking” in the *ACM Viewpoint* publication (p. 33). Wing’s (2006) article has been widely cited primarily because it was an attempt at reinvigorating the field of Computer Science by highlighting that the thinking skills learned through Computer Science could be applied in a wide range of disciplines (Astrachan et al., 2009, p. 549).

The following pages will highlight several papers which demonstrate some of the key debates within the discourse of computational thinking. These debates will be tracked by first looking at the history of computational thinking and Wing’s initial and subsequent definition. The next topic will discuss how “computational thinking” became contentious with both researchers and educators when they were unsure of what definition of computational thinking to use. Finally, this section will look at how in recent years there seems to be a consensus being reached about how to use the term "computational thinking", especially when it comes to pre-graduate education, even while there continues to be some debate as to the best definition.

A number of key authors have proved to be particularly prolific on computational thinking; in particular, Wing and Denning have each written numerous papers and articles on the subject (Denning, 2009, 2017; Denning et al., 2017; Tendre & Denning, 2016; Wing, 2006, 2008, 2011, 2014, 2017), and in doing so, have defined what could be seen as two opposing camps. Wing advocates a version of Computational thinking which equates to general thinking skills that applies to a wide range of disciplines. Denning (2009, 2017) advocates for a definition of computational thinking far more grounded in computer science.

3.4.1 The Beginnings of Computational Thinking

Denning relates the term "computational thinking" back to the 1950s and 1960s along with other terms such as "algorithmic thinking"—in other words, formulating problems in such a way that their solution could be expressed as an algorithm (Denning, 2009, p. 28). Even as early as 1962, there were calls for all university students to learn computer programming as a way to improve their problem-solving abilities. As it became more evident that teaching programming wasn't necessarily a practical approach, the ideas around computational thinking emerged as a way of teaching concepts without teaching programming (Guzdial, 2008, p. 25).

The more recent use of the term "computational thinking" (CT) generally is traced back to Wing's 2006 article (Tendre & Denning, 2016, p.124; Wing, 2006, p. 33). Wing's 2006 article presents computational thinking as a "fundamental skill for everyone" (p. 33). Wing's initial article was criticised for not giving a clear enough description of how computational thinking was unique to Computer Science or even to using computers and was not just another way of talking about critical thinking skills (Hemmendinger, 2010, p. 4). Wing returned to the area several times to refine her view of computational thinking (Wing, 2008, p. 3717; Wing 2011, p. 20; Wing, 2014, p. 2) In her subsequent articles, she more clearly presented her definitions of computational thinking:

> *1) Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent (Wing, 2011, p. 20)*

And in similarly 2014,

> *2) Computational thinking is the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer—human or machine—can effectively carry out. (Wing, 2014, np)*

Wing's underlying point is that computational thinking is a skill that will benefit everyone in society, whether or not they use computers, and that everybody has the ability to "think like a computer scientist" (Wing, 2014, np). There has been much debate regarding Wing's approach to computational thinking, specifically the role of programming in CT (Lu & Fletcher, 2009, p. 260), whether unique to Computer Science (Hemmendinger, 2010, p. 4), and whether it is valuable to everyone (Tendre & Denning, 2016, p. 125).

Teaching Computer Science concepts through computational thinking lessons has become more relevant with the growth of the "CS for All" movement, which has advocated that every child learn basic Computer Science as a core skill of living in a computerised world (Denning et al., 2017, p. 31; Tendre & Denning, 2016, p. 122). The move to educate more young people about Computer Science and computational thinking has, at least in Denning's opinion, led to a major misconception about both computational thinking and Computer Science. Denning asserts that not every task can be broken down into step-by-step procedures or should be considered "computational", and that there is no evidence that learning computational thinking makes people better problem solvers (Denning et al., 2017, p. 33).

One of the most important distinctions that Denning draws is the need to be clear when talking about teaching computing, Computer Science, programming, and computational thinking. They are all distinct and separate (although related) subjects, and should not be considered interchangeable (Denning, et al., 2017, p. 32). This confusion is not helped by the enthusiasms of those computer scientists and those with an interest in Computer Science who seem to feel that if only everyone were a computer scientists (or at least thought like one), the world would be a better place (Denning et al., 2017, p. 33; Hemmendinger, 2010, p. 6). Hemmendinger (2010, p. 6) suggests that a better way to think about teaching computational thinking would be the following:

> *Teaching computational thinking, however, is something else; not to lead people to think like us [computer scientists]— which is pretty varied anyway. Instead, it is to teach them how to think like an economist, a physicist, an artist, and to understand how to use computation to solve their problems, to create, and to discover new questions that can fruitfully be explored. Computer scientists can contribute, but we should be careful not to speak as if we are the ones to lead people to a promised land.*

Despite the criticism of Wing's approach to computational thinking, her message is a positive one: that "Computational Thinking is the new literacy of the 21st century" (Wing, 2010, p. 3). Wing presents an articulate argument that all children will benefit from being taught a version of computational thinking (Wing, 2008, p. 3722).

3.4.2 The Debate About What Computational Thinking is and is Not…

Once the topic of "computational thinking" had become part of the academic discourse regarding computing education, several authors noted that the lack of a standard or agreed upon definition of computational thinking presented a challenge when trying to use the concept in an educational setting (Aho 2012, p. 833; Barr and Stephenson, 2011, p.49; Gouws et al, 2013, p. 10; Kranov et al., 2010, p. 143; Yadav et al., 2014, 5:2). Kranov et al. (2010, p. 143) stated that computational thinking "lacks a precise and widely-adopted definition—even within the field of computer science. The lack of precise definition of CT at the national level was one of the first challenges we faced in bringing our multidisciplinary community together."

Barr and Stephenson (2011, p. 49) also found difficulties: "developing a definition of, or approach to, computational thinking that is suitable for K-12 is especially challenging in light of the fact that there is, yet, no widely agreed upon definition of computational thinking" (p. 49). Similarly, Gouws et al. (2013) stated that "there is widespread agreement about the importance and relevance of Computational Thinking; however, there is little consensus on a formal definition for Computational Thinking, and discrepancy in beliefs of how it should be integrated into educational programmes" (p. 10). Such difficulties continue in more recent literature: for example, Selby (2015, p. 2) points out the continuing confusion over the term computational thinking, and Yadav et al. (2017, p. 55) highlights the need for a definition that can be put into practice, specifically for education.

In many cases, authors have tried to highlight what is wrong with one interpretation of "computational thinking". Aho suggests that there was not enough information on a "computational model" to make computational thinking valuable to teaching Computer Science (Aho, 2012, p. 833), and Denning (2017) presents concerns that "…in an effort to be inclusive of all fields that might use computing, the recent definitions of computational thinking made fuzzy and overreaching claims" (p. 32). Other authors, attempted to propose, uncover, or develop an "agreed" understanding of computational thinking. For example, Ahamed, et al. (2010, p.42) conducted a three-day workshop with high school teachers to develop an understanding of computational thinking, and Kranov, et al. (2010, p. 143) conducted multi-disciplinary projects across 19 diverse colleges and universities in the Pacific Northwest of the United States to develop a shared understanding of computational thinking.

Through reviewing this literature, three predominate approaches to computational thinking have arisen. These can be classified as the general problem-solving approach, the computational model approach, and the programming approach. A more complete description follows.

The General Problem-Solving Approach.

Wing uses the phrase "thinking like a computer scientist" and considers computational thinking as a general problem-solving skill that can be applied broadly: "computational thinking is the thought process involved in formulating a problem and expressing its solution(s) in such a way that a computer can effectively carry it out" (Wing, 2014, p. 1). The thought is that this approach to computational thinking is relevant to everyone as everyone can benefit from learning to "think like a computer scientist" (Wing 2008, p. 3718). While a solution might be expressed in a way that a computer could carry it out, this does not mean it must or that the solution is explicitly expressed in computer code (Wing 2008, p. 3718). As Gouws et al. (2013, p. 10) think of it, "therefore, computational thinking is not about thinking like a computer, but rather thinking about problems from a computational perspective" (p. 10). In this approach, the core of computational thinking is the ability to identify patterns and generalise from a specific instance—a process referred to as abstraction (Wing, 2014, p. 2). The general problem-solving approach to computational thinking focuses not on forming a solution to a problem in a certain way (for example, using code or pseudo-code), but rather on thinking about any number of problems in a certain way and using the framing of that problem to formulate any number of solutions (whether computationally relevant or not).

The Computational Model Approach.

This is the approach promoted by Denning (2009, 2017) and most clearly explained by Aho (2012, p. 832). This approach to computational thinking puts the emphasis on computing and on understanding the "model of computation" through which a problem will be *solved*: "a model of computation is a mathematical abstraction of a computing system"—in other words, understanding the mathematical theory on which the computational model is based (Aho, 2012, p. 833). This form of computational thinking requires an understanding of both what "computational models" are in general and an ability in expressing and understanding the specific "computational model" being applied as part of computational thinking (Denning, 2017a, 2017b; Denning et al., 2017; Tender & Denning, 2016). This form of computational thinking requires one to be a computer scientist with an understanding of computational models and some degree of computational notation (programming) to use appropriately (Aho, 2012, 833-835). Aho (2012) presents a deceptively simple definition of computational thinking but uses the term "computation" in a specific rather than general way: "We consider computational thinking to be the thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms" (p. 833).

The Programming Approach.

The programming approach, in essence, sees computational thinking as the skills needed to write computer programs; central to the programming approach is the premise that computational thinking can be taught through teaching programming (Ahamed, et al., 2010, p. 44). In the programming approach, whether implicitly or explicitly, programming is seen as the 'best' or only way to express a computational solution (Lye & Koh, 2014,p. 51). Lye and Koh (2014) conducted a review of all studies which examined teaching computational thinking through programming, taking as their premise both that: 1) teaching programming should also involve teaching computational thinking and 2) that computational thinking can (and should) be taught through teaching programming (Lye & Koh, 2014, p. 58). The nature of the programming approach is that computational thinking is seen as intrinsically linked to programming because the definition of computational thinking has shifted to be more in line with concepts that are valuable when creating programs. For example, Brennan and Resnick (2012, p. 3) identify the following seven computational thinking concepts: sequences, loops, parallelism, events, conditionals, operators, and data. While these are viable concepts connected to computational thinking, Brennan and Resnick (2012) framed these concepts specifically in the context of the Scratch block-based programming language.

As an alternative to the programming approach described above, Lu and Fletcher (2009, 261) proposed the development of a computational thinking language, which would use some computational terminology without making it necessary for pupils to learn a computer language to become practiced in computational thinking. Lu and Fletcher's (2009) premise was that: "programming is to CS what proof construction is to mathematics and what literary analysis is to English" (p. 261) and suggested that computational thinking should be taught much earlier than programming, through the use of a notation (or computational thinking language) designed specifically for teaching computational thinking. Lu and

Fletcher's (2009) approach to computational thinking is significantly different, so is considered a separate, distinctive 'pre-programming' approach.

While these models of computational thinking highlight the main debates within the field of computing education, there are other approaches to understanding and teaching computing and computational thinking in practice. A number of institutions have attempted to teach computing, computer science, and computational thinking to non-Computer Science graduates, using many different models ranging from studying the key people who have employed computational thinking to giving science majors a firm foundation in basic programming and establishing an understanding of basic algorithmic thinking (Astrachan et al., 2009, p. 549-550).

What these approaches grapple with is the question of whether students need a special set of thinking skills to make better use computers to solve problems in the 21st century (Barr et al., 2011, p. 23). The struggle for researchers and educators is that, while computational thinking remains loosely defined, it is difficult to agree on ways to teach it (Kranov et al., 2010, p. 144), and how it should be distinguished from other forms of 'critical thinking' and 'problem solving' (Barr et al., 2011, p. 22). In essence, the meaning of computational thinking has evolved over time, starting out as describing how scientists in a range of fields could use computers to better investigate disciplines such as physics, biology, and engineering, only to then be taken up by computer scientists and, more recently, be seen as a general skill for a general population to solve problems using computer technology (Denning, 2017a).

3.4.3 Computational Thinking and Education

From the emergence of the more recent discourse of computational thinking, the suggestion has been that it should become the fourth primary skill alongside reading, writing, and arithmetic (Qualls & Sherrell, 2010). Much of the motivation for discussing computational thinking as a 'general skill' from which everyone one can benefit has been to increase the interest in computing and Computer Science education (Wing, 2010). Much of the discourse now takes as a given that computational thinking should be taught, in some form, in all compulsory education with several attempts to create a definitive definition for widespread use in education (Voogt et al.,2015, p. 716).

The general problem-solving approach has been mostly widely adopted when it comes to the introduction of computational thinking in compulsory education. This is partly because this framing of computational thinking is that if it is applicable to wide range of situations it can be taught to anyone (Qualls & Sherrell, 2011, p. 80).

For Wing (2014, p. 2) the core of computational thinking is abstraction—which she sees as the ability to define "patterns, generalising from specific instances, and parameterisation" (p. 2). A number of other concepts have been added to abstraction to offer a working definition that has been applied to teaching practice. For example, Selby (2015) proposes a definition that includes decomposition, abstraction, algorithm design, generalisation, and evaluation. Similarly, in the Barefoot/ Computing at School classroom material for teachers (Fig 3), computational thinking concepts include: logic, algorithms, decomposition, patterns, abstractions, and evaluation (Barefoot, 2020).

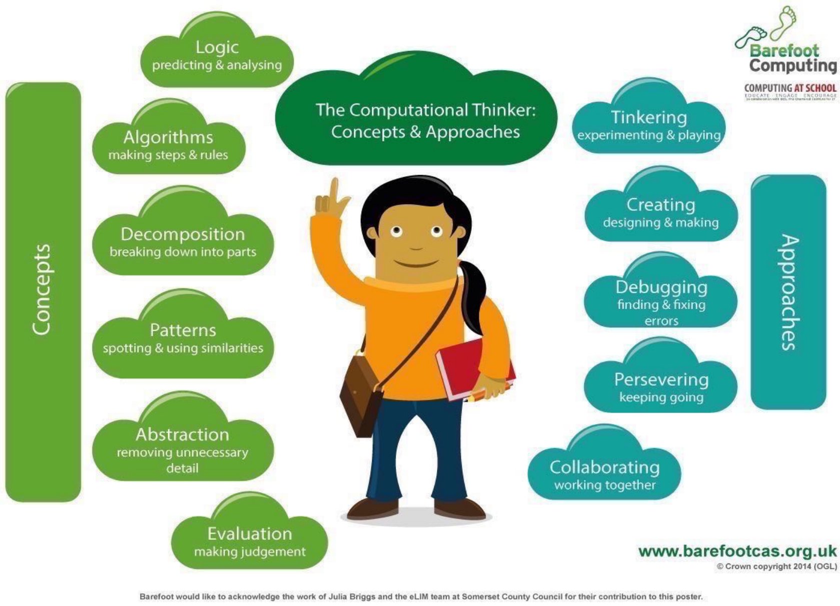

Figure 3: Poster of Concepts and Approaches for Computational Thinking.

Other definitions of computational thinking used in other parts of the world (Europe, the United States, and Australia) also include: data collection, data analysis, data representation, problem decomposition, abstraction, algorithms, automation, parallelisation, and simulation (Mannila et al., 2014, p. 2; Yadav et al., 2017, p. 57). While in the UK context the 'data' aspects of computational thinking are often (but not always) left out with more of a focus on a problem-solving approach.

As computational thinking is being proposed by some authors such as Yadav et al. (2017) and Israel et al. (2015) as a general skill—they feel that it could also be taught in a cross-curricular manner. For example, English teachers could embed algorithms into writing through activities like writing recipes and instructions (Yadav et al., 2017, p. 61). To reach this goal, computing, and specifically computational thinking, would need to be integrated into all teacher training in a coherent fashion (Yadav et al.,2017, p. 62). Israel et al. (2015) documented a case study where computation thinking was integrated in a cross-curricular manner in a small elementary school in the USA (Israel et al, 2014, p. 263).

Debate is still ongoing as to what exactly computational thinking entails and whether it should be taught across the curriculum or only specifically within a computing context (Voogt et al., 2015, p. 726). However, as this section has identified, the literature includes three different approaches to computational thinking— the general problem-solving approach, the computing approach, and the programming approach. In the UK, the approach mainly promoted for use in schools is the general problem-solving approach which sees computational thinking as a general skill which can help a broad population solve problems while using computers (Computing at School, 2015).

3.5 Conclusion of the Literature Review

This chapter has reviewed the literature regarding the three key academic discourses which are most relevant to the formulation of the 2014 English computing Curriculum: digital economy, digital literacy and computational thinking. Strikingly common across each of these three themes is the lack of a clear definition or agreed understanding, both in general usage and in terms of education.

Digital economy.

The economic argument for computing education has been that pupils need to be prepared for the digital economy in spite of little clarity about precisely what is meant by the term digital economy. To help to address this lack of clarity, this thesis has deconstructed the concept of the 'digital economy' into three phases: pre-Internet digital economy, digital economy 1.0 (or console-based digital economy), and digital economy 2.0 (or the mobile digital economy). By examining the digital economy in these phases, computing education can be analysed and understood through this framing. Most young people in Key Stage 3 and broader society in England are already engaged in the digital economy 2.0 through the use of mobile phones and tablets. The question remains: does the computing curriculum take into consideration the developments of the Digital economy?

Digital literacy.

Digital literacy is identified as an underpinning skill for computing. A number of definitions range from basic competence to a more complex set of skills and competencies.

This thesis will follow a three-fold understanding of digital literacy: the use of digital tools, the information those tools give one access to, and how one uses digital tools to communicate and connect with others on a social and emotional level, including understanding the impact and consequences of one's activity online.

Computational thinking.

The computational thinking literature exhibits a healthy and sometimes heated debate about what computational thinking is. This thesis has identified three approaches: *the general problem-solving* approach, *the computational model* approach, and *the programming* approach. This thesis will most closely adopt the general problem-solving approach, since this is the approach most commonly taken in schools. However, variations from this will be noted in the classroom studies, most notably regarding the relationship with the programming approach.

This thesis will now move on to outline the methodological approach used to formulate research questions and collect data to answer the research questions.

Chapter 4: Methodology, Method and Approach to Research

4.1 Introduction to Methodology

This chapter outlines the methodology and methodological approach taken to complete this thesis and is organised in four sections. The first section examines the choice of methodology, including the research design taken, the epistemological approach, how the research questions were arrived at, and what kind of research will be conducted. The second section looks at how the data in this study has been collected, including why a certain approach to data collection has been undertaken in comparison to other methods. The third section explores the data analysis procedures, including the initial codes that were used. The final section covers two important issues—ethical considerations and how validity was ensured within the project.

4.2 Research Design, Philosophical Approach and Choice of Method

Research design is the process of developing a framework for the collection and the analysis of data (Bryman, 2004, p. 27). The purpose of the research design is to set out the fundamental aspects of the enquiry including the underpinning issue of the research, the kind of research being undertaken (and why it is appropriate to the context), the specific methods being used, and the approach to data including how it will be analysed (Cohen et al., 2011, p. 223).

Cohen et al. present a model of research design that is a check list that can help the researcher remember what to include in their research design that can include the following elements: research questions, deciding role and managing entry, ethical issues, data collection in the field, data analysis, leaving the field, writing the report, field relations, locating informants, data collection outside of the field, sampling, deciding field of study (Cohen et al., 2011, p. 224). Cohen et al.'s (2011) conception of all of these contributes equally to the centre of qualitative research design.

Luttrell (2010b, p. 161) focuses on research relationships, examining how the researcher relates to both participants and the context of the research. Luttrell's stance is that, as qualitative research is fundamentally about people, the research design should fundamentally be about how the research relates to the people involved. This work is particularly relevant to this research project for two reasons: first, it was designed for research in educational settings, and second, it highlights how the research questions are returned to throughout the process (Luttrell, 2010b, p. 161).

For this thesis, a research model has been adopted which envisions a hierarchical structure that better represents how the research progresses through time (Fig 4). The research questions reoccurred from the point of the epistemology onwards reflecting that the research questions were formed and reformed throughout the process of conducting the thesis.

The following section will now look at the epistemology of this study. Qualitative studies tend to have less strictly defined research designs and allow more room for innovation (Creswell, 2009, p. 19).

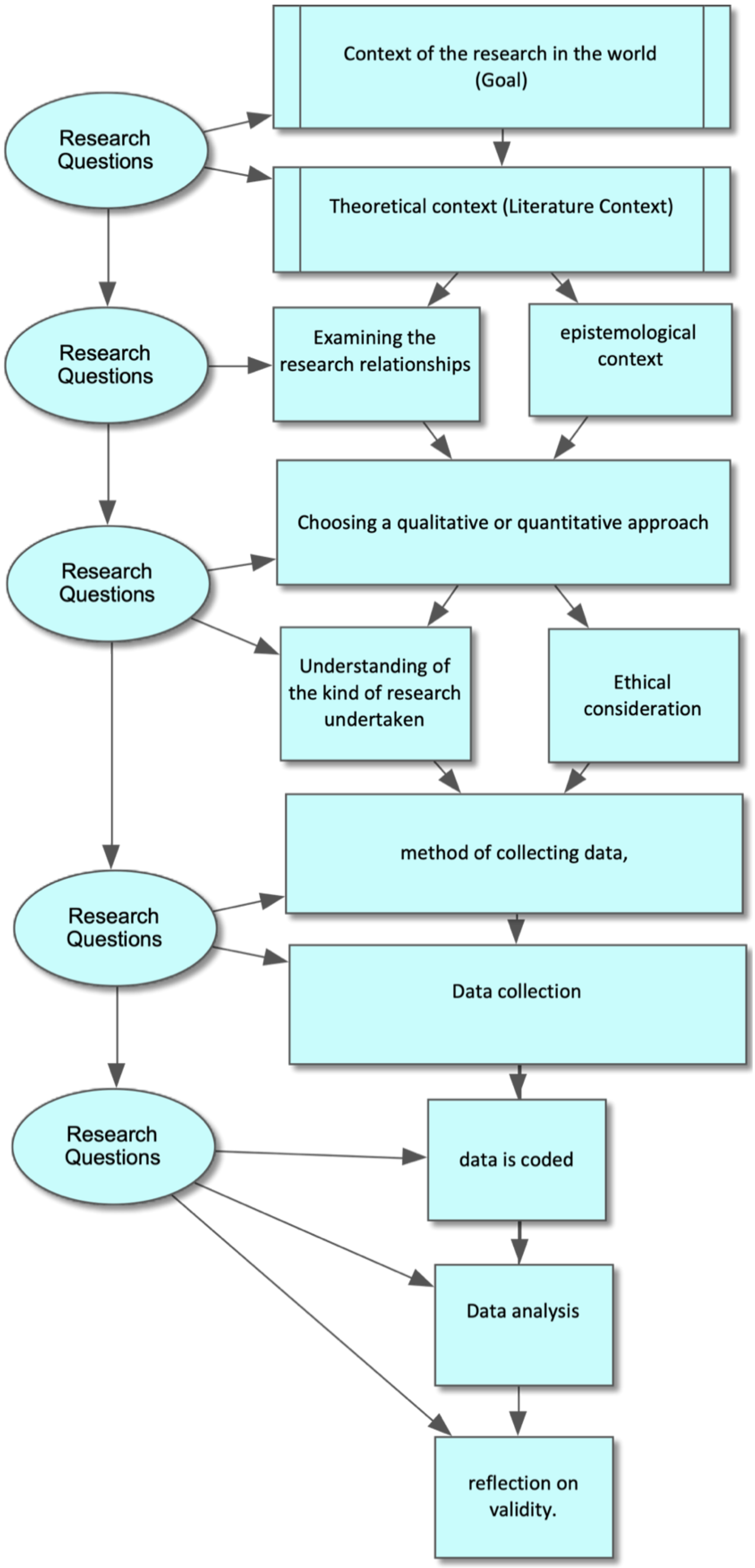

Figure 4: Research Model

4.2.1 Philosophical Underpinning of Approach

In any research that involves human participants, the researcher must acknowledge whether they are approaching the project from a positivist or constructivism philosophical standpoint. Positivism is based on the epistemological standpoint that there is an objective reality that is independent from any human observer. The researcher is trying to uncover this reality or truth through deductive reasoning, developing hypotheses, and objective experimentation (Cohen et al., 2011, p7; Creswell, 2009, p. 7). Constructivism views reality itself (or in so far as it can be known and experienced by people) as a social construction (Bryman, 2004, p. 17). Constructivism is sometimes used to refer to the social construction of the 'social world' (Creswell, 2009, p. 8).

In the case of this study, the research questions are concerned with both pupils' experience of the English computing curriculum and acknowledging that the experience of an individual is a socially constructed experience.

Notably, the key terms 'digital literacy' and 'computational thinking' are equally socially constructed concepts. It would not be possible to investigate them purely by looking at data. Instead, they must be investigated through exploring with participants what the terms have come to mean, and how they have come to be applied. Rather than focusing solely on how the participants understood these terms directly, the research proceeded by exploring the terms 'digital literacy' and 'computational thinking' in the academic literature and then comparing them to the experiences of the pupils. This allowed the researcher to directly reflect on the themes of the research in comparison to the experiences of the pupils, not expecting them to have a direct understanding of these terms, but to compare their life experiences to conceptions of digital literacy and computational thinking encountered in the literature.

The digital economy theme is slightly different as it could potentially be approached from a positivist epistemological standpoint. However, as the literature survey within this thesis has discussed, there is little consensus as to what the truth or fact of the digital economy is. Consequently, the digital economy has been more appropriately seen as something that is also being socially constructed.

4.2.2 Qualitative Approach

The distinction between a qualitative and quantitative approach is sometimes seen a false distinction, as the two approaches often have much in common and can be mixed together effectively (Cohen et al. 2011, p. 15). Others have argued that, rather than being superficial, the distinction between the two approaches to research are far deeper and go beyond the type of data collected (Bryman, 2004, p. 19).

In regard to this research, a qualitative approach has been utilised. The research drew on new and emerging fields, including computing education and digital economy. This research looked at the socially constructed experience of pupils towards the computing curriculum. By taking a qualitative, constructivist approach, this research can collect data about individuals' experiences and use it to develop insights that lead to conclusions which can be used to inform policy, practice, and future studies. Within this field, there has been limited research which examines the pupils' experience from a purely qualitative approach. This research will look at the pupils' experiences with computing education as it relates to the digital economy, digital literacy, and computational thinking.

4.2.3 Research Questions

The purpose of a well-formulated, qualitative research question is to narrow the approach to the methodology which helps the researcher to better understand what sort of meaning the research project is looking for (Bryman, 2004, p. 31; Mills & Birk 2014, p. 10)

As is often the case, the research questions within this study have evolved through many forms, being revisited and reformed at almost every stage of the study's development (Mills & Birks, 2014, p. 10). Qualitative research questions aim to explore a topic rather than look for a specific (numerical) answer. They are usually phrased in such a way that begins with words such as 'how' or 'what' (Cohen et al. 2011, p. 110; Creswell, 2009, p. 129).

For this research project, a central research question has been selected that focuses on pupils' experiences with the English computing curriculum. In addition, a number of sub-questions have been formulated that will be answered through the data collected. Each sub-question draws on an aspect of the overarching question and corresponds to one of the three core themes of the thesis (Bryman, 2004, p. 32).

Research Question.

To what extent do the young people subject to the English computing curriculum as delivered at Key Stage 3 and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

Sub Questions.

1. How do KS3 pupils and teachers understand the digital economy and broader digital world and how are the pupils understanding being shaped by the delivery of 2014 computing curriculum?

2. Do KS3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?
3. What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?

These research questions focus on the experiences of young people as they are subjected to and affected by computing education in the early years of the implementation of the 2014 computing curriculum. The young people's insights allow for reflection on the broader impact of the computing curriculum (how it is affecting the pupils' understanding and approach to the world) and creates the opportunity for future research to examine how the impact of the computing curriculum has changed over time. While the primary purpose of this research was to gather and document the experiences of young people, the thesis recognises many other stakeholders have valuable insights into the 2014 computing curriculum. As a result, qualitative data relating to teacher experiences and reflections of 'experts' from the field are also gathered.

The research design for this project is qualitative and the research question needs to be answered through interaction with participants.

4.3 Research Approach

Several kinds of research designs could be applicable for this sort of research; these are case study, phenomenology and grounded theory, and will be discussed below. Comparative study, longitudinal study, action research ethnography, and design-based research (DBR) were not considered appropriate for this project (Anderson & Shattuck, 2012, p. 2-3; Cohen et al., 2010, p. 222; Creswell, 2009, p. 13; Mills, 2014, p. 35). Comparative study was not seen as relevant although research was conducted in multiple sites since the sites did not have enough variation to be distinct cases. Each site of enquiry was chosen specifically for its similarity to the experience of the pupils. As this project was restricted to a three-year Ph.D. thesis, it was not possible to conduct a longitudinal study. However, future work may want to take this approach. This project was also not adequately positioned to be action research, as the researcher was an outsider coming into the classroom. Action research requires the researcher to have a position of influence over the site of data collection and aims for action. Action research is also based on a cyclical approach based on a repeated process of design—act, reflect, repeat; this process would not have worked for this project. Design-based research, while often used in education, was considered too intervention-focused for this project. Similar to longitudinal studies, an ethnographic approach would require extended time spent in the field. This project aimed to focus on a specific aspect of pupils' reported experiences rather than drawing heavily on the researcher's observations (Anderson & Shattuck, 2012, pp. 2-3; Bryman, 2004, p. 46; Cohen et al., 2010, p. 222; Creswell, 2009, p. 13; Dick, 2014, p. 41).

The main challenge regarding research questions is determining which research approach will allow the researcher to approach the field in such a way that the research questions could be adequately explored within the constraints of the project (Cohen et al., 2010, p. 222). The three research approaches considered for this project were:

- Case Study
- Phenomenology
- Grounded theory.

Each of the potential research approaches will be briefly outlined followed by a description of the approach used in this study.

Case Study.

Case studies are used in a wide range of disciplines and are used to give intensive descriptions of a single or small number units of enquiry. A case study approach could be appropriate for this study as case studies are best used for answering “how” or “why” questions (Stewart, 2014, p. 145) When conducting educational research, a case study can be a powerful tool. It is presumed to provide a detailed description of the case as well as a description of what makes that case both unique and generalisable (Bryman, 2004, p. 49; Cohen et al., 2011, 293).

Phenomenology.

Phenomenology as a research approach, comes out of the philosophical school of the same name. It is closely associated with the philosopher Heidegger who argues in his book *Being and Time* that to understand or describe the world is to interpret it and, in essence, subject, object, and context are indistinguishable (Heidegger et al., 2013, p. 192; Usher & Jackson, 2014, p. 185; Weinberg, 2014, p. 30). Using a phenomenological approach would require more of an emphasis on the participants’ understanding of their experiences. In the case of this particular research project, the question is whether the focus is on how pupils construct meaning around the computing curriculum or whether the thesis is more interested in how pupils are experiencing the computing curriculum in terms of the stated aims of the curriculum itself. By emphasising the stated aims of the curriculum, phenomenology becomes a less appropriate method to use on its own.

Grounded theory.

Grounded theory is based on the work of Glaser and Strauss, who proposed it as both an approach to data collection and analysis of qualitative data (Suddaby, 2006, p. 633). The purpose of grounded theory as an approach is to give equal weight to both theory and practice as the researcher moves between them to generate data which leads to theory (Glaser & Strauss, 2006, p. 4). The purpose of grounded theory is to move from data to theory rather than the other way around (Mills et al. 2014, pp. 112-113). In terms of data analysis, grounded theory is a process that can be used to draw conclusions out of complex and extensive qualitative data—the approach to data analysis will be returned to later in this chapter.

The research questions presented are in direct response to UK government policy action in the world—the implementation of the 2014 English computing curriculum (and not the teaching of computing in school as such). As is the case with many cross-disciplinary projects, the research has necessitated movement back and forth between the field and existing literature, as data is collected and literature from different disciplines is considered (Fig 4) (Suddaby, 2006, p. 635). This approach of moving between data, literature, and theory is consistent with a grounded theory approach and has been selected as a research method. As field work has been conducted, literature was revisited and reselected to better understand the researcher's experience in the field. This movement was also necessitated by working in a quickly moving field where the theoretical framing has changed over time. This movement has been used to revisit and revise the research questions, rather than to revise a theoretical stance.

4.3.1 Answering the Research Questions

The purpose of this research project is to work toward addressing the research questions. In order to do this, a pragmatic research approach has been taken. After conducting the initial fieldwork, the researcher found that the culture and community of the school setting was far more complex than could be explored though solely investigating how computing was being taught.

For this thesis, a pragmatic grounded approach towards the research has been used. Although some elements of case study research are included (selecting multiple sites of research), as are some aspects of phenomenology (as the research has explored how pupils create meaning out of their computing education), the research is most consistent with a grounded theory approach. As the project moved from data to conclusion, it used a grounded approach to data analysis to draw meaning out of the experience of participants, as gathered through qualitative group interviews and extended interviews. Each of these methods has limitations that would make it difficult to use any one of them individually for this project. By using aspects of all three, deeper insight into the data is possible.

4.3.2 Data Collection

The methodological approach used in this study was to conduct *in-depth* fieldwork in a single school consisting of several weeks of developing an understanding of the content being delivered, the culture of computing lessons and developing a rapport with participants, and conducting five group interviews with pupils and in-depth interviews with the two computing teachers. This was followed by *lighter-weight* fieldwork in two additional schools to add more breadth and depth to the data. This consisted of fewer group interviews (three in school B and one in school C) and further teacher interviews (two in school B and four in school C). In addition to interviewing the young people, the computing teachers at each school were also interviewed to better understand the context of computing education and its impact on the young people. While speaking to the young people to understand their experiences was essential, their perspective is also limited. The interviews with teachers (Chapter 6) provided further insight into the experience of young people learning computing, contributing to the discussion and recommendations presented in Chapter 7. Three further validation interviews with 'experts' from the field were also conducted towards the completion of the project (see Sections 4.5.2 and 7.6).

Through this combination of interviews and direct observation, the researcher was able to observe the pupils and teachers and have a minimal impact on the behaviour of the participants, while simultaneously being able to follow up with interviews and use open ended questions for the interviewees to reflect on their actions and their situations (Maxwell, 2010, p. 282).

4.3.3 Interviews and Group Interviews

Within this project, to answer the research question, interviews were conducted with both pupils and teachers. These two different groups required the use of different approaches. Where the teachers could be interviewed one-on-one and could speak for an extended time with the researcher, the pupils were available for a shorter amount of time. It is also considered best practice where possible to interview young people in a group setting, as it "encourages interaction between the group members rather than just responding to the adult's questions" (Cohen et al., 2011, p. 433).

All interviews for this project were recorded, the interviews were then professionally transcribed, but the original recordings were kept securely and also used directly during the analysis stage to check consistency of transcription, tone, and meaning of ambiguous statements. The recordings were also used to check places where transcribers could not understand the statements due to accents or background noise (Bryman, 2004, p. 331; Jones, 1984, p. 58). This was in line with the ethical approval from the Lancaster University Ethics Committee (see Section 4.5.1).

After having conducted five 20-54 minute interviews in school A, the researcher then conducted 4 additional group interviews with pupils in school B (three, between 42-57 minutes long) and C (one, 21 minutes long). Alterations were made to the question proforma after the first set of interviews to reflect a tighter focus on the research questions; however, the format of the interview remained the same.

Pupil Interviews.

For this project, pupils were typically interviewed in groups of six with the groups being chosen by the teacher. The groups were all taken from a single computing class setting so that they all knew each other and had had a relatively similar experience with learning computing.

Prior to the researcher visiting the school, pupils were sent parental consent forms that were completed and checked before any interviews took place. Prior to the interviews, pupils were given an interview guide (see Appendix I). For all but the interviews in school C, the normal classroom (computing) teacher was not present. A total of 54 pupils took part in the interviews for this project, with about seven total hours of interviews with pupils.

School A: Total pupils interviewed 30, length of interview 20-50 minutes, all pupils in year 9.

- Interview 1: Year 9, 6 pupils: 3 male, 3 female (43 minutes)
- Interview 2: Year 9, 6 pupils: 3 male, 3 female (38 minutes)
- Interview 3: Year 9, 6 pupils: 3 male, 3 female (20 minutes)
- Interview 4: Year 9, 6 pupils: 3 male, 3 female (29 minutes)
- Interview 5: Year 9, 6 pupils: 3 male, 3 female (54 minutes)

The researcher then conducted four additional group interviews with pupils in School B (three group interviews) and C (one group interview). These interviews followed the same format of the interview as in School A, but had more variation in group composition: a year 7 group were also selected for study, partially due to availability, but also since they were a group of high performing students who had achieved high results on a problem-solving test and who had asked to take part in the researcher project. Interviewing them was useful to have a degree of understanding of how pupils who were at the beginning of KS3 responded to the questions.

In school C, there was less time available for young people interviews and only one interview was conducted with a group of year 10 pupils during their lunch time break. The group of year 10 pupils were interviewed during a lunch time 'club' at school C. These students had moved from KS3 and into their GCSE choices.

Before conducting the second set phase of group interviews, the researcher listened to the recording of all the previous interviews to ensure consistency and to better focus the interview questions.

School B: Total pupils interviewed 18, length of interview 42-57 minutes, year 7 & 9 pupils.

- Interview 1: Year 9, 6 pupils, 2 males 3 females, (45 minutes)
- Interview 2: Year 9, 5 pupils, 3 males 2 (42 minutes)
- Interview 3: Year 7, 7 pupils, 4 males, 3 females (57 minutes)

School C: Total pupils interviewed 6, length of interview 25 minutes, year 10 pupils.

- Interview 1: Year 10, 6 pupils, 3 male and 3 females. (25 minutes)

Teachers.

Interviews with teachers were slightly different from the interviews with pupils. It was possible to interview the teachers for a longer time and the teachers, being adults, were also better able to articulate their views and opinions (Cohen, 2011, p. 425). A combination of both semi-structured and unstructured interviews was used with the teachers involved in this project. Initially, only semi-structured interviews were used, but as the interviews were conducted it became clear that many teachers had important things to say that did not fit within the interview question proforma. As such, an 'unstructured' approach was also employed. A total of nine teacher interviews were conducted over 10 hours and 40 minutes.

Table 2 - Details of Interviews with Teachers:

Reference	**School**	**Role**	**Interview time**	**Interview type**
Teacher 1	School A	Head of Technology	90 min	Semi-structured
Teacher 2	School A	Computing Teacher	84 min	Semi-structured
Teacher 3	School C	Head of Computing	53 min	Semi-structured
Teacher 4	School C	Computing Teacher	61 min	Semi-structured With Unstructured parts
Teacher 5	School C	Computing Teacher	55 min	Unstructured
Teacher 6	School C	Computing and Technology Teacher	118 min	Semi-structured With Unstructured parts
Teacher 7	School B	Head of Computing	73 min	Semi-structured
Teacher 8	School B	Computing Teacher	77 min	Semi-structured
Teacher 9	School B	Member of SMT Responsible for Computing	26 min	Semi-structured With Unstructured parts

4.4 Approach to Data Analysis

It can be a complex process to separate where data collection ends and data analysis begins. The reality is that these aspects of the study are intermingled; data analysis starts as you are collecting the data, as you code, as you record, think, look for themes, but most of all as you ask the question— does this feel right? (Silverman & Marvasti, 2008, p. 193)

A grounded approach to analysis was used for data collected in this study. This section will be looking at how and why these methods of analysis were chosen.

Following a grounded theory analysis approach, the researcher approached the raw data to look for patterns within the data, finding themes which are shaped into abstractions (Creswell, 2009, p. 175). At each stage of the data collection process, the data was reviewed, notated, and initial codification conducted while keeping in mind the wholeness of the data at the early stages (Cohen, et al., 2011, p. 238).

Qualitative analysis can quickly result in large amounts of data as the researcher uses transcribed interviews, photographs, and field notes to try abstract meaning from their time in the field (Bryman, 2004, p. 398). A way of viewing this initial process of working the material is that, once the material collected from the field is abstracted and codified, the interviews, transcribed notes, and photographs become data, which is then analysed (Mills, 2014, p. 42).

At its most basic tenet, qualitative analysis is the process of finding a number of broad themes within in the data. Often this process is done by using codes that emerge from the data (Creswell, 2009, p. 184). Throughout the coding process memos, or notes can also be used to keep track as codes come together in general themes and become analysable units of information (Charmaz, 1988 p. 120). More recently, researchers who use coding for the analysis of qualitative data will use a software package to help keep track data, codes, and memos. This can save time if there is a significant amount of data (Creswell, 2009, p. 188).

In this project, software was not used to analyse data. Also, as the same person did the research as well as the analysis, a high level of familiarity with the raw interview data was considered central to the analysis process.

Coding can be criticised because it has a tendency to fragment the data, and the researcher, through the process of analysis, can lose a sense of the whole (Bryman, 2004, p. 411). While conducting the analysis for this project, the raw transcripts and recording of the interviews were referred back to in an effort to ensure that statements and phrases were not taken out of context.

4.4.1 A Grounded Theory Approach to Coding Data

There are a number of ways to systematically code qualitative data. The most common way to code data is the application of the grounded theory approach to coding data (Creswell, 2009, p. 184). With grounded theory, there are three phases of coding— open coding, axial coding, and selective coding. Each phase is conducted consecutively and builds on the previous phase, building a more abstract and manageable view of the collected data (Bryman, 2004, p. 402; Charmaz, 1988, p. 111; Cohen et al., 2011, p. 560; Mills et al., 2014, p. 111).

Theoretical codes used at the open coding and axial coding stages of the process are advanced abstractions that will be worked into the further development of a theoretical framework. This framework can then be used to explain the data (in its abstracted form) and, potentially, used to define the theory which could explain the data (Mills et al., 2014, p. 115).

The selective coding stage requires a deep understanding of the data or what is referred to as the storyline of the data, which can lead to the creating of the core category. These categories are related to the dimensions identified and the relationships between categories are then validated by returning to the data and filling any gaps in the categories (Cohen, 2011, p. 462).

Open Coding.

Open coding, also called initial coding, is considered to be the first phase of coding qualitative data. During the first phase of coding, the researcher fractures the data into smaller segments for comparison with other data. The data is interrogated to determine its relevance to the study and what it is saying (Mills et al., 2014, p. 114). While conducting open coding, a first set of codes is used, then revised and revisited. This process involves reading and rereading the transcripts of interview data—getting a sense of the whole of the interview and then finding the codes that can be used to find a find a first level of meaning in the data (Charmaz, 1988, p.113).

Axial Coding.

Axial coding is also referred to as intermediate coding, or focused coding. During this phase of coding, categories are generated and the researcher may begin to generate a general theory (Mills et al., 2014, p.114). At this point, connections are made between categories. This is done by "linking codes to context, to consequences, to patterns of interaction, and to cause" (Bryman, 2004, p. 402). Data can then be represented, either metaphorically or in diagrams, on an axis where comparisons and contrasts can be highlighted. Towards the end of the axial coding process, the researcher aims to saturate the categories with data; this can be done by going through existing data or, where needed, returning to the field to collect more data (Mills et al., 2014, p.115). Axial coding is about making connections between subgroups within a single category as well as between one category and another (Cohn et al., 2011, p. 562).

Selective Coding.

Selective coding is the final phase of coding in grounded theory and is also called either advanced coding or theoretical coding. During this phase of coding, core categories of investigation are selected. In traditional grounded theory, these core categories are the advanced abstractions that are built up into the development of a framework that can be used to explain the data (in its abstracted form) and, potentially, the theory (Mills et al., 2014, p. 115). For this thesis, these selective codes have been used to start to work towards policy recommendations, identifying potential areas for future research, and identifying areas of potential future theory. The core category has also been referred to as the "storyline". In this thesis each theme (Digital Economy, Digital Literacy and Computational Thinking) has acted as a three pronged 'storyline' – overall the 'storyline' is the relationship of each of these themes to how they have been implemented and explored through the English Computing Curriculum. What has emerged from the data and moved the research forward is how the data from the young people and teachers have informed this 'storyline', outlining the overall impact of the curriculum on the young people in regards to each of these themes.

Selective coding requires a deep understanding of the data, or what is referred to by Corbin and Strauss as the "storyline" of the data (Bryman, 2004, p. 402), which can lead to the creating of the core categories. These categories are then related to the dimensions identified, and then the relationships between categories are validated by returning to the data and filling any gaps (Cohen, 2011).

4.4.2 Open, axial and selective codes used to analyse the data.

To analyse the data for this project, an initial list of codes was used to look at the group interview data. This list of codes was developed through initial engagement with the data as well reflecting on the research questions and the overall purpose of the project to reflect on how pupils and teachers are experiencing the English computing curriculum.

Each interview was first coded for the three themes of this thesis: digital economy, digital literacy, and computational thinking. Each transcript of a group interview was coded for these themes and turned into three separate documents that only included the sections that related to the theme. These coded documents were then read through and the researcher made 'memos' and notes regarding the broad themes of each section, quotation and fragment. By completing these fragments, the patterns and 'open' codes emerged from the data and, as each new code was created, previous memos were examined to see if these sections too may fit in one of the emerging open coding areas. Once a full transcript was fully annotated, quotes and sections relating to each open code were examined to see what axial sub themes were represented in each open code. For example, in the area of 'Digital Economy', the open code of 'people' emerged as interviewees talked about how 'people' interact with the digital economy. Within this 'open' code, the further 'axial' codes emerged of 'the people of the digital economy' (the people who pupils thought worked in the digital economy), 'the dark side' (where the pupils, or people used the digital economy for negative ends, like hacking), and, 'how people of different ages engage with the digital economy'. These documents were then read through and selected for the key 'selective codes' – these decisions were based on the code's relationship to the overall theme of the thesis and data storyline, and codes and themes that occurred the most often within the data. From the example, the selective process focused on 'The people of the digital economy', which is further explored in section 5.2.1 of this thesis. The eleven selective codes that emerged from this process by theme were:

- Digital economy: people, describing the digital world, engaging in the digital world,

- Digital literacy: social media, online communities, work versus leisure, knowledge and skills,
- Computational thinking: computer science, computational thinking, thinking like a computer scientist, programming.

From these initial open codes, the axial codes emerged, highlighting the various ways the interviewees viewed these topics. Each axial coded set of data was then read for key insights and importance to the research questions. The selective categories emerged from this final reading of the data.

Looking at this process in practice, the transcripts were first filtered by theme grouping all quotes that related to each theme into a single document. In figure 5, a quote from a student has been pre-sorted into a document called "Digital Economy". The quote has then been given the meme/comment of "can be used for good and evil" – from this comment it has been put into the category of "the dark side" which is part of the broad category of "people".

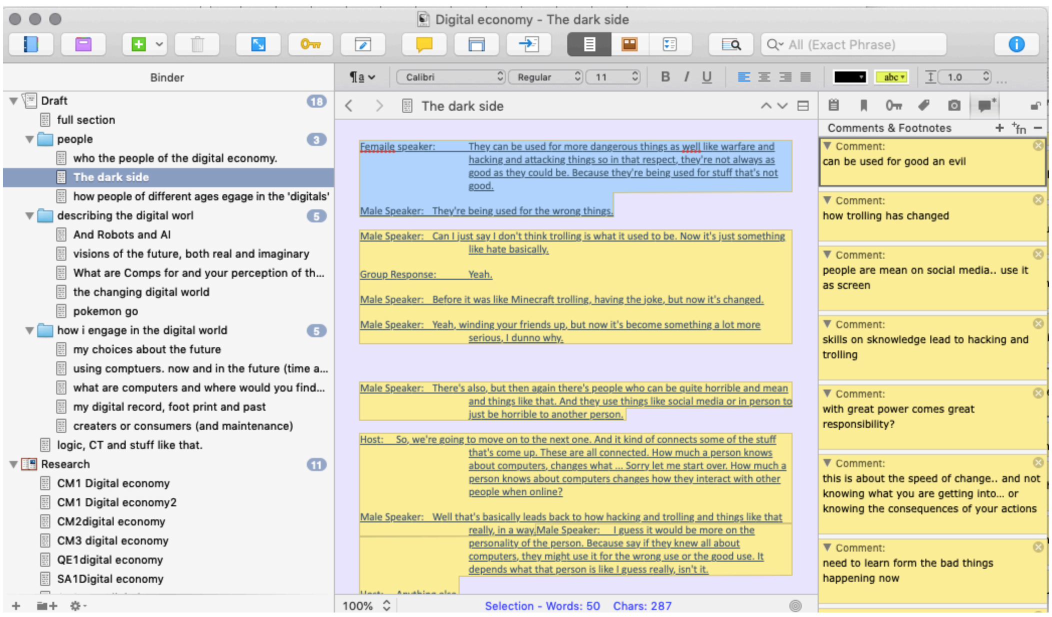

Figure 5: Digital Economy Axial Coding Example

This same quotation, at the following (selective stage) has been further sorted into the abstraction “Feeling of anxiety, overwhelmed and …and pressure to keep up” which has been re-categorised as a “describing the digital world” (Fig 6).

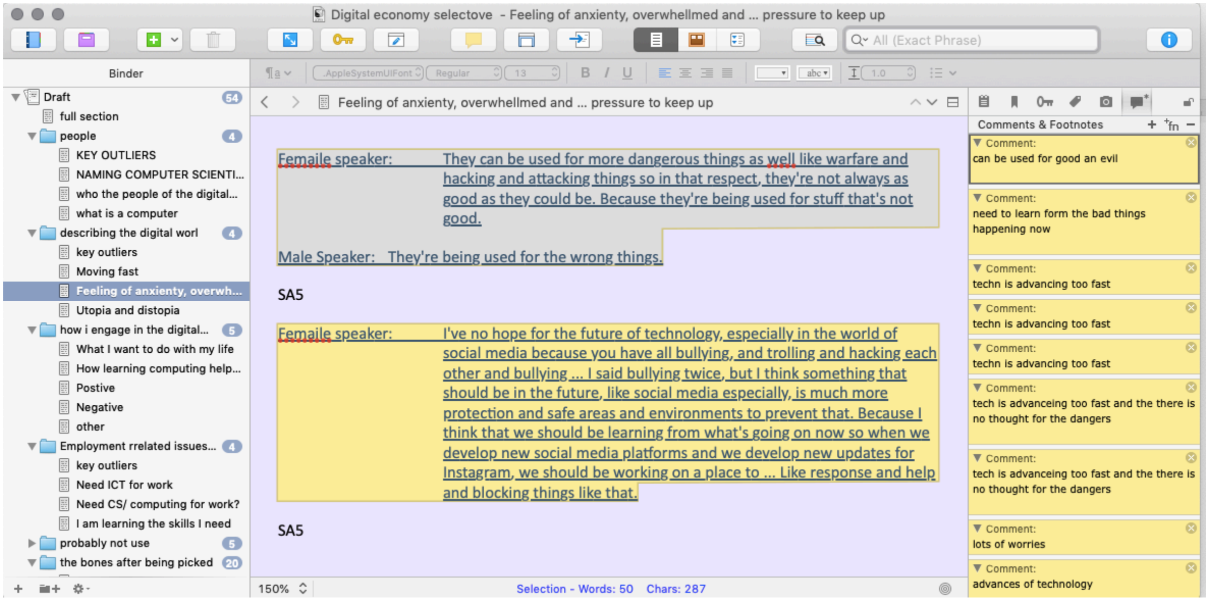

Figure 6: Digital Economy Selective Coding Example

Similarly in Figure 7, a quotation which is considered about “digital literacy”, where the student speaks about being in contact with a relative who lives overseas (in Portugal) and using social media to stay in contact, has been given the memo/comment of “speaking to people overseas” and has been placed in the category “Online communities people I don’t know or see everyday”, which has been further categorised into the broad code of “Online Communities”. In this example, the axial nature of this stage is clearer as there is also a category for “Online communities - people I know or go to school with”. Further axial categories can be seen regarding “work vs. leisure”. (N.B. This stage of analysis is for the researcher to make sense of the data, in this case the researcher is dyslexic, so there are spelling mistakes in the coding process).

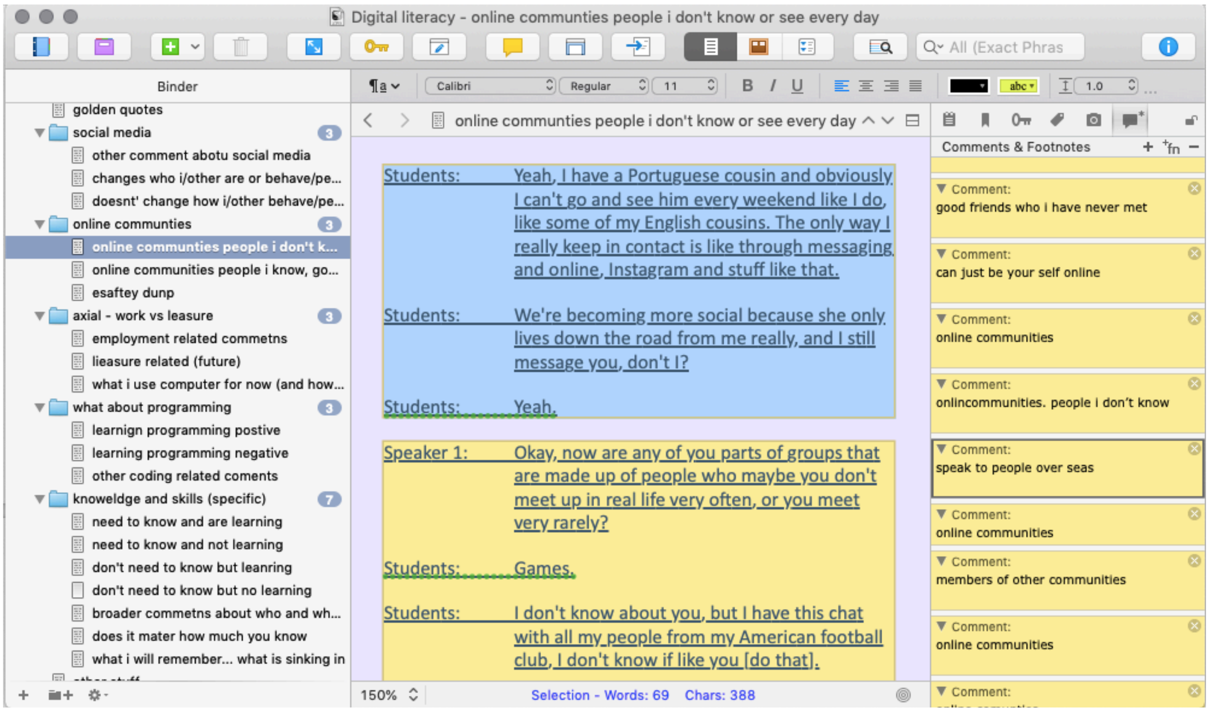

Figure 7: Digital literacy Axial Coding Example.

The full set of codes used for this project can be found in Tables 4-6 at the end of chapter five.

4.5 Ethics and Validity

The following section considers the two final, but vital, aspects of the methodological approach for this project—ethics and validity. These two areas are presented together because they are both aspects of the methodological approach which require broader reflection on the methodology as a whole. The purpose of the consideration of the ethics within this project is to ensure that all participants are adequately protected from any potential harm by being involved in the project. The purpose of the section on validity is to consider both how to ensure the findings of the study are true but also to reflect on how the findings of a study of this kind can have meaning in the world.

4.5.1 Ethics

An essential part of any project is reflection on an ethical consideration, which is particularly the case in a research project that involves human or animal participants. There are also a number of ethical considerations specific to qualitative research when using either interviews or observational research because the researcher will come into direct contact with the participants, build up a degree of rapport with them, and, therefore, has a degree of responsibility or obligation to the individuals involved in the project.

As this project worked with minors, further ethical considerations needed to be taken as young people are, by definition, a vulnerable group. Clear guidelines need to be followed for conducting school-based research but, fundamentally, all research must take into account the effect of the research on the participants and act in such a way as to preserve their dignity as human beings (Cohen, et al., 2011, p. 84).

Bryman (2004, p. 509) presents four questions of ethics that a project needs to address to ensure it is proceeding in responsible way. These are:

- Is there *harm to the participants?*
- Is there a *lack of informed consent*?
- Is there an *invasion of privacy?*
- Is *deception* is involved?

Ethics approval was sought and granted from Lancaster University's Faculty of Science and Technology (FST) before any interviews or research took place. Hence, all documents—including, informed consent forms and indicative questions—had been reviewed and approved in advance.

Harm to Participants.

Harm in the context of research is not just a question of physical harm; it can come in many forms. For example, harm can occur in the form professional criticism or loss of dignity. Van Maanen (1988, p. 281) stated that inevitably someone will be angered, and thereby harmed, by any social research as it is often reporting on matters that someone would rather be kept quiet. In regard to this project, there was more of an ethical risk for the teachers, as Malin (2003, p. 23) points out. The publication of research that could cause a teacher embarrassment is a dilemma, when even if the names are changed the teacher may recognise their own practice (Malin, 2003, p. 23). For example, in the case of the findings stating "x, y, or z should not be taught like this or that", a teacher may feel quite offended should they think this is a description of how they themselves teach. This risk is minimised, in the case of this research, as the primary aim is not to improve teaching practice or better understand how pupils learn, but rather to understand a policy's impact—through the curriculum—on pupils. In short, this research is focused on the impact of content rather than the process. Which is to say, even where teachers may feel critiqued, the project is critically looking at how they deliver computing within the constraints of the National Curriculum, rather than on an individual level. Further to this goal, schools that participated were chosen because they had been previously identified through prior engagement with University and Computing at School-led professional development and networking. Additionally, they had been identified as teachers who were teaching computing to a high standard. The project was fully explained, including any risks, to gatekeeper teachers before any research took place (Cohen, et al., 2011, p. 83).

To ensure the risk of harm to dignity is minimised, there are number of key guidelines which require that school-based research is done to a standard that ensures the dignity of both teachers and pupils is respected fully. Cohen et.al. advise adhering to the following 6 principles in their ‘Conditions and Guarantees for school-based research projects’ (Cohen et al., 2011, p. 83)

1. All participants must be given the chance to remain anonymous.
2. All data must be given strict confidentiality.
3. Interviewees should have the chance to verify statements as the stage of drafting the report (respondents’ validation)
4. Participants should be given a copy of the final report.
5. Permission for publication must be gained from the participants.
6. If possible, the research report should be of benefit to the school and participants.

In regard to this project, these principles were adhered to the following ways:

1. All participants remained anonymous—initially identified only by first names and then during the analysis process, only by using pseudonyms. In the final report these pseudonyms have been applied where quotations have been used and any identifying statements have been removed.
2. All data has been treated as confidential and sensitive.
3. Transcription of the interviews were sent to teachers once the transcription had taken place. As the researcher could not have direct contact with pupils and did not want to pass transcription of group interviews through the teacher (for confidentiality reasons), pupils were informed during the interviews they could request the transcript should they wish to see it.
4. The final copy of this thesis will be available to participants,
5. The intent to publish was clearly laid out in the consent forms.

Although the purpose of the final report is not directly for the benefit of the schools, part of the purpose of an executive summary, to be shared amongst participants, was to reframe the findings in such a way that the schools could reflect on how they might be relevant to practice in the schools directly.

Informed Consent.

Informed consent is the allowance and agreement by the participants to take part in the research (Bryman, 2004, p. 511). From a practical level, to gain access to this data it was necessary to gain consent from the pupils, the teachers, and the parents of the pupils involved (Cohen et al., 2011, p. 79). This was achieved by producing three separate versions of a participant information sheet and consent form (Appendix I)—one for teachers, one for parents, and one for pupils (for the observational aspects of the research). There was also an additional consent form for pupils who wished to take part in the group interviews. Teachers were sent the participant information forms and consent form prior to the research taking place, and no classroom observations took place until the consent forms had been returned to the teacher. Teachers sent the consent forms to parents with an introduction about the school's participation in the research.

The following guidelines for informed consent from Cohen et al. were used as reference in the preparation of the consent forms (Cohen et al., 2011, p. 78).

1. A fair explanation of the procedures to be followed and their purposes.
2. A description of the attendant discomforts and risks reasonable to be expected.
3. A description of the benefits reasonably to be expected.

4. A disclosure of appropriate alternative procedures that might be advantageous to the participants.
5. An offer to answer any enquiries concerning the procedures.
6. An instruction that the person is free to withdraw consent and to discontinue participation in the project at any time without prejudice to the participants.

Only one pupil in one class did not give consent to take part in the observational aspect of the research. As it was only one individual, research still took place during the pupil's lessons, but this particular pupil was not included in any research material (such as photographs), the researcher did not interact with this pupil, and this pupil did not take part in the group interviews. All pupils were also again asked for verbal consent before being asked questions in class and before taking part in the group interviews. For example, the researcher would approach a participant in class and ask, "would you mind if I take picture of your work?" or "May I ask you about your work?" Pictures that included pupils' faces, or anything else that would make them identifiable, were avoided.

Deception and Invasion of Privacy.

Within this project, the possibility of deceptions and invasion of privacy is low, as the nature of the data collected does not need to be sensitive or deceptive. In terms of the interviews conducted—in both the cases of the group and individual interviews—if any participants expressed that they did not have an answer or did not want to answer a particular question, that was accepted and the interview moved to the next question. Equally, anonymity was maintained throughout. Particularly in the case of the group interviews where pupils were asked to state their name for use in transcription, they were told it was perfectly fine, should they wish to, to use a pseudonym. After transcription all names were pseudonymised

(Bryman, 2004, p. 513). Equally, the pupils were assured that answers would not be relayed directly to their teachers and would not reflect on their progress or achievement in computing class.

In the case of teachers, the interviews were longer and more in depth. These interviews were all conducted in a location where the teacher felt comfortable, such as an office or empty classroom.

All participants were given the interview question proforma prior to being interviewed and were able to ask questions about the nature of the question before the interview was conducted.

There was no need for the deception of participants in this project. The researcher was introduced to teachers before coming to the schools, was introduced to the pupils at the beginning of any lesson being observed, and all participants were given multiple opportunities to ask for clarification about the project. This is not to say there was no deception at all, as with all social research it is not possible to fully explain (in detail) the nature of the research (Bryman, 2004, p. 514). However, every effort was made to be as transparent as possible for the participants.

Final Thoughts on Ethics.

It should be reiterated that the purpose of this research was to examine the effect of the 2014 national curriculum for computing on pupils. Which is to say, if there is ‘harm’ in the delivery of the curriculum, one must determine if it is because of the nature of the curriculum or because of the delivery. This is also why, after the initial observational research conducted in school A that was conducted for context, the primary means of data collection proceeded to interviews with teacher and pupils. This was an intentional attempt to focus on their experiences rather than falling into the trap of appearing to question the delivery of the curriculum.

4.5.2 Validity, Reliability, Credibility and Validation

The purpose of research is to uncover findings that add to knowledge in a particular field. In order to do this, it is essential that those findings are valid, reliable, and credible (Birk, 2014, p. 221). In qualitative research, it is essential to look at approaches to ensure the quality of qualitative research, sometimes highlighted using terms like ‘trustworthiness’, ‘credibility’, ‘confirmability’, ‘dependability’, ‘consistency’, ‘transferability’, or ‘neutrality’ (Birks, 2014, p. 221; Cohen et al., 2011, p. 200).

Ultimately, whatever word is used, validity requires thinking about the relationship between the conclusions and reality (Maxwell, 2010, p. 279). Do the conclusions presented in the findings of a given research project reflect an accurate picture of reality that the researchers observed in order reach conclusions? When it comes to assessing the validity of a qualitative research project, the purpose is not to assess if an objective truth has been arrived at; nor is the purpose to attain some sort of ultimate truth, but rather to be able to confidently state that accounts of the reality as presented in the data and the conclusions are credible (Maxwell, 2010, p. 280).

There are two primary validity threats in qualitative research—researcher-bias and researcher-reactivity. Researcher-bias is when the researcher’s beliefs, theory, or perceptual lens affect what data is collected, or how the data is analysed (Creswell, 2009, p. 192; Maxwell, 2010, p. 281). Reactivity on the other hand is where the very presence of the researchers, or the fact of the researcher is asking the questions, changes how participants in the study behave or respond to the questions (Cohen et al., 2011, p. 208; Maxwell, 2010, p. 282; Van Maanen, 1982, p. 283). When planning a research project, a researcher must consider and plan how to deal with these threats to the validity to the conclusions of the study.

Steps Taken to Ensure Validity.

In order to plan to reduce bias and increase validity of this study, several steps were selected that used Maxwell's (2010) suggested checklist as starting point. The checklist for this project was based on four steps:

1. Involvement in the setting and the Computer Science Education community, including attending events and trainings with educators involved in Computing education: The researcher ensured to engage in the computing education community in a number of ways. These activities meant that the researcher had an obligation and commitment to accurately reporting on the world of computing education as it exists not as the researcher may think it exists, thus warding off the validity threat of researcher bias (Creswell, 2009, p. 193; Maxwell, 2010, p. 283).

2. Collecting rich data: Like other forms of qualitative projects, rich descriptions of the research site should be the aim. This is collected through having detailed transcripts (and retaining the recordings) of interview data, and by keeping detailed field notes to refer to from observational data (Maxwell, 2010, p. 282). To accompany the field notes in this study, the researcher also took photographs of the pupils and teachers in their normal computing lesson (in line with ethics and permissions given by pupils and teachers; identifying features such as faces were avoided).

3. Comparison: Three techniques have been used to ensure a degree of comparison and validity of the research. In this research project, data was collected from three separate sites. Secondly, as explained in point 1, the researcher worked closely within the computing education context throughout the project having many informal conversations with educators and researchers of their experiences of the computing education by attending trainings, networking events, and conferences, ensuring that the findings of the study reflected of a general experience of computing education in the UK (Maxwell, 2010, p. 285).

4. Respondent Validity and Validation: Respondent validity was conducted by using interviews with teachers from the same schools and then, finally, interviews with external experts. Teacher interviews were used to supplement the data and findings from the pupils' interviews. Interviews with teachers were different from the interviews with pupils. They were long and the teachers being adults also were better able to articulate their views and opinions (Cohen et al., 2011, p.425). A combination of both semi-structured and unstructured interviews was used with the teachers involved. In addition, three additional expert interviews were conducted in January 2020, providing validation for the findings and recommendations concluded from this project (see Table 3). Further details regarding the expert's validation interviews are presented in Chapter 7 (Section 7.6).

Table 3 - Details of Validity Interviews with Experts Conducted in January 2020:

Name	Organisation	Role	Interview time	Interview type
Expert 1	National coding organisation	Coordinator for the Northwest	80 minutes	Semi-structured
Expert 2	Secondary school similar to the others involved in the study	Head of IT	88 minutes	Semi-structured
Expert 3	University with focus on teacher education	Principal Lecturer in Education	67 min	Semi-structured

Final Comments on Validity, Reliability, and Credibility.

This chapter represents the concurrent stages of data collection and analysis procedures which will be used to draw conclusions, find meaning, develop the narrative, and to present a response to the research questions. Rather than directly answering the research question, a qualitative approach uses the questions as a guiding point to move through the data and present conclusion discussion (Luttrell, 2010a, p. 6). This study is setting out to present a valid description, an uncovering, and a revealing of a reality.

On a final note, Creswell (2009) points out that, validity of a qualitative study cannot be based on the amount of data gathered. Rather, it should be judged by the quality of observations the researcher uses to documents their approach, the use of reliable procedures (for collection and confirmation), and on the degree of transparency that is possible for each step of the study (Creswell, 2009, p. 193).

4.6 Conclusion

This chapter has looked at the methodological approach used for this PhD project, covering the research design and philosophy. It also discussed how the research draws on a constructivism epistemology as it is looking at reality and truth as it is constructed by individuals. This chapter then presented the research questions used to investigate the nature of reality in this instance. A qualitative approach was used for this research, drawing on three approaches: case study, phenomenology, and grounded theory—drawing predominantly on grounded theory for data analysis.

In order to answer the research questions, data was collected through interviews. Young people were interviewed using semi-structured group interviews. Group interviews are seen as a very good way of investigating young people's views on a given topic. During the course of the research, teachers were interviewed using both semi-structured and unstructured interview processes. Subject experts were then interviewed at a later stage of the project to provide validation.

Finally, this chapter has considered ethics and validity. A number of steps were taken to ensure that this research was conducted in an ethical manner; these have included having a rigorous process of informed consent as approved by the Lancaster University Faculty of Science and Technology Ethics Committee.

Validity is a key question for any research project as it answers the questions ‘how do we know if the truth statements made in this thesis are true?’. This project used four processes or steps to ensure the findings were valid; these included involvement in community of study, collecting rich data, comparison, and validation interviews.

Through using this process, it has been determined that the research is a reflection of reality and the conclusion contribute to the field of computing education and curriculum development.

Chapter 5: Data Presentation.

Looking at the Data Regarding, Digital Literacy, Digital Economy and Computational Thinking.

5.1 Introduction to Data from the Young People

This chapter will present the data for this thesis, primarily drawing on the nine group interviews with young people (as outlined in Section 4.3.2). This chapter aims to present the data in the student's own words wherever possible. In some cases, the students' words have been summarised, particularly in places where a single idea was expressed in more than one interview. The interviews for this project were semi-structured (interview template available in appendices III-IV). As a project drawing on a grounded methodology, the interview templates developed over time. They were returned to after each interview to consider if there were any areas that needed to be more thoroughly explored or re-focused. As the interviews were semi-structured, there was flexibility as the conversations were allowed to flow in a natural format. In terms of structure, individual students have not been identified but the gender of students is indicated where more than one speaker is involved. Multiple speakers are indicated by a number, but this number is only for reference within each quote and does not identify a single speaker from quote to quote. Group interviews were used to allow for conversation and discussion between participants and, where possible, this conversation has been represented.

As presented in Chapter 1, the overarching research question and the subsequent sub-questions are:

Research Question.

To what extent do the young people subject to the English computing curriculum as delivered at Key Stage 3 and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

Sub Questions.

1. How do KS3 pupils and teachers understand the digital economy and broader digital world and how are the pupils understanding being shaped by the delivery of 2014 computing curriculum?
2. Do KS3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?
3. What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?

This chapter presents the outcomes of discussions that took place during the group interviews with the young people. Each subsection will focus on one to the three themes of the computing curriculum: digital economy (relating to sub question one), digital literacy (relating to sub-question two), and computational thinking (relating to sub-question three). The concluding part of this chapter will come back to the overarching research question. At the beginning of each section, the definitions of each of these themes, developed through the literature context, will be presented and the data aims to be presented in such a way that they relate back to these definitions.

Each section is loosely structured around the definitions of each themes developed in Chapter 3, even where the data does not relate exactly back to these definitions, as this is the nature of the process of collecting qualitative data. There is a messiness to the data. The grounded coding process is conducted to filter and analyse the data which removes some of this unruliness. These interviews reflect the lived experiences of individuals, specifically young people, who may not have the academic experience or language to discuss their experience in such a way that it might fit easily into the prescribed categories.

The codes used for analysing the data were developed through moving between the themes of the thesis (digital economy, digital literacy, and computational thinking), the literature (described in Chapter 3), and the data itself.

The open, axial, and selective codes were described in section 4.4.2 and listed in tables 3-5 at the end of Chapter 4. While the selective codes, for the most part, remained relevant to the research questions, a number of areas arose as emerging themes which took on greater importance than the literature may have indicated. In particular, in the theme of digital economy, it emerged that young people had a particular view of the people that made up the digital economy and had a surprising number of concerns about the development of digital technology. In the theme of digital literacy, while social media and people's behaviour online seemed peripheral to the literature, these were central the young people's experience with digital literacy. Computational thinking, quickly emerged as a murky area in the comments of the young people, while the role of programming in the delivery of computing became of central important to the interviews. It also emerged across the interviews that there was a certain degree of confusion regarding the terms "computing", "Computer Science", and even "ICT".

This chapter will proceed with sections focusing on each of the three themes. Within these themes, the subsections focus on either the open codes or, in cases where the open codes proved too broad, the selective code. For example, the open code "how I engage in the digital world" has become "thinking about their own future".

5.2 Data Regarding Digital Economy

In Section 3.2.2, this thesis presented the idea that the digital economy could be understood in three phases: pre-Internet digital economy, digital economy 1.0, digital economy 2.0, with a developing understanding of what may be the nature of future digital economies.

While the students are not thinking about the economy or their economic future in these terms, aspects of their experience follow this progression closely. Section 5.2.2 shows they are aware of their grandparents being uncomfortable with Internet technology (being a generation that grew up in the pre-digital economy), they observe their parents using tools (such as office type software) which would be associated with digital economy 1.0, and they experience daily the technologies of digital economy 2.0. Section 5.2.3 discusses the pupils' questions and concerns about the technologies which would be associated with a future digital economy, such as the Internet of Things and smart home technology. They do not feel they understand these new devices and have many concerns based on this lack of knowledge.

As stated in Section 3.2.3, digital economy generally refers to the process of digitisation and the growth of the importance of the Internet and World Wide Web to business. If discussing young people 'working in the digital economy', then this would be referring to young people working in a sector that could not exist without this digitisation and internet access. While other job roles may rely on the digital economy (DE 1.0) to operate, they are not part of the digital economy (DE 2.0).

Sub-question one asks:

1. How do KS3 pupils and teachers understand the digital economy and broader digital world and how are the pupils understanding being shaped by the delivery of 2014 computing curriculum?

This section initially looks at how young people view the people and technologies of the digital economy by exploring the people they think of having influenced the field of computing. Then this section looks at how they describe the digital world that they experience and examines their thoughts about their future and how they will interact with the digital economy in the future.

5.2.1 The People and Things of the Digital Economy: What is a Computer Scientist?

Students' understanding of the digital economy is important because it shapes their choices for the future. As shall be shown, one of interesting aspects that emerged from the discussions regarding the digital economy with the young people was what their preconceptions were regarding what a computer scientist might be and even what a computer might be.

The young people were asked to name three computer scientists. As the data shows, the young people demonstrated a great deal of confusion as to what (or who) a computer scientist might be. This showed that the young people had a very narrow view what a computer scientist might look like.

Computer Scientists Cross-Referenced to Interviews.

As a warm-up question at the beginning of each group interview, the young people were asked if they could name three computer scientists or people who had influenced the field of computing.

The purpose of this question was to get the young people thinking more about computing and get them comfortable with the discussion format. The purpose was not to ask them what they thought a computer scientist does.

The young people named a range of different people as computer scientists. While there is no doubt that individuals such as Bill Gates and Steve Jobs have had a tremendous influence on computing, there are many other individuals from a range of backgrounds that have also influenced this field. The wide range of individuals named makes it seem that the young people were not entirely sure what was meant by a computer scientist.

Alan Turing (School B, Interview 1, School C, Interview 1 School A, Interview 5)
Ada Lovelace (School B, Interview 2, School A, Interview 5)
John Boole (School C, Interview 1)
Tim Berners-Lee (School C, Interview 1)
Von Neumann (School C, Interview 1
Bills Gates (School B, Interview 1, School B, Interview 3, School B, Interview 2, School C, Interview 1, School A, Interview 1, School A, Interview 2, School A, Interview 3, School A, Interview 4)
Steve Jobs (School B, Interview 1, School B, Interview 3, School B, Interview 2, School C, Interview 1, School A, Interview 1, School A, Interview 2, School A, Interview 4, School A, Interview 5) (12)
Mark Zuckerberg (School B, Interview 3, School B, Interview 2, School A, Interview 5)
Gabe Newell (School B, Interview 2)
He made Apple. (School A, Interview 1)
Microsoft (School B, Interview 1, School B, Interview 2, School A, Interview 1, School A, Interview 2, School A, Interview 3, School A, Interview 4, School A, Interview 5)
Napster (School B, Interview 3)
Shaun something (School B, Interview 3)
Steve Wozniak (School A, Interview 2)
Stephen Hawking (School A, Interview 1, School A, Interview 5, School A, Interview 3)
Albert Einstein (School B, Interview 3, School B, Interview 2, School A, Interview 1, School A, Interview 2)
Isaac Newton (School A, Interview 3)
Brian Cox (School A, Interview 3, School A, Interview 4)
Alexander Graham Bell (School B, Interview 3)
Charles Darwin (School A, Interview 2)
Pythagoras (School A, Interview 1)
Mr Male teacher 1(School A, Interview 4)
Mr Male teacher 2(School A, Interview 4)
Darah O'Briain. (School A, Interview 4)
Julius Caesar (School B, Interview 2)
Ms. Novacaski (School A, Interview 5)
Sheldon Cooper (School A, Interview 4)
Stephen Spielberg (School A, Interview 5)

Table 4 - Computer Scientists Name by Pupils (Numbers Indicate the Number of Times the Name was Mentioned):

Historic Figures from Computing	**Contemporary Figures form computing**	**Scientists in General**	**Other people**
Charles Babbage (7) Alan Turing (3) Ada Lovelace John Boole Tim Berners-Lee Von Neumann	Bills Gates (14) Steve Jobs (12) Mark Zuckerberg (5) Gabe Newell. He made Apple. Microsoft. Napster Shaun something Steve Wozniak	Stephen Hawking Einstein (3) Albert Einstein (2) Isaac Newton (2) Brian Cox (2) Alexander Graham Bell Charles Darwin Pythagoras	Mr Male teacher 1(3) Mr Male teacher 2(3) Dara O'Briain. Julius Caesar Ms. Novacaski Sheldon Cooper Stephen Spielberg

Computer Scientists.

A number of key observations became apparent through this question. The majority of the names the young people mentioned were white men—ranging from the (Science and technology) TV presenter Dara O'Briain to Sheldon Cooper (from the popular TV show the "The Big Bang Theory"). Both of these TV personalities are associated with science and technology in general. Several young people mentioned the physicists Stephen Hawking and Brian Cox; some of the young people were confused between Stephen Hawking and Steve Jobs but several knew that Steven Hawking was a scientist who used a computer to communicate.

Student (F): Stephen Hawking did like-

Student (F): Yeah, because he has found a way to speak when he can't speak.

Student (M): Exactly.

Student (F): He uses a computer to physically speak.

Student (M): I don't know, but technically he's the one who inspired other computer scientists. I guess you could say.

Student (F): I'm guessing he's the one that's inspired other people to start looking further into computer development.

(School A, Interview 5)

The most mentioned names were Steve Jobs and Bill Gates, both associated with Apple and Microsoft, respectively. Many pupils who could not come up with any other computer scientists, named both of these men quickly. Mark Zuckerberg was mentioned and also associated with starting and owning Facebook. While the computer curriculum was motivated by desire to inspire young people to take up computing fields, the young people seemed to have little idea of what this might entail, what sort of a person might do this, or of role models who do not fit the current stereotype of a computer scientist. It is worth noting that many of the non-computer scientists the young people named, drawn from a wide range of areas, all also fit a stereotype of a computer scientist as male and Caucasian.

While John Boole, John Von-Neuman, and Tim Berners-Lee were all mentioned, all three of these names emerged in the same group interview (School C, Interview 1), the one group interview with a group of students in year 10 (instead of year 9). It is possible that these students had a better sense of what a computer scientist might be AFTER they had chosen to continue computing as an elective subject. Similarly, though, names from a limited demographic were offered.

5.2.2 Describing the Digital world

The young people were asked to think about the future of technology by considering what skills they might need and how they viewed the advances in technology. This discussion led to them being able to consider their future job roles and the skills they thought they might need for their future job roles. This was also a chance to reflect on how they felt the computing curriculum was 'preparing them to take part in the digital economy and future digital world'.

Moving Fast.

One group of young people felt that in the future most technology would be "too advanced for us to actually use" (School A, Interview 5). What was meant by this is that there would be a split between those who could use the technology available (those who had the skills to use computer) and those who did not, but also that many uses of computers might be restricted because of the fear of hacking.

Student (M): Yeah, and the thing is because they're trying to rush it because people want it, more and more people are craving technology-

Interviewer: Do you think people want it?

Student (M): I think yeah, young people wise as well mainly would ... Are craving new technology, new models.

Interviewer: You mean like you and your friends?

Student (M): Young people in general really, from the age of what, 8 to 20, young 20's. (School A, Interview 5)

Student: I think there are more important technological advances we could be making, like sciences and stuff, rather than new features on iPhones. (School A, Interview 1)

The young people were asked to consider the future and advancements in technology. While the purpose of this discussion was to consider the extent that what they were learning would relate to how they would use computing in the future, many of the young people reflected on the pace of change in terms of technological advances and expressed concern in regards to the future digital economy that they would be expected to take part in.

Students: New, new product that everyone has.

Interviewer: Do you feel as kind of people in the world, do you feel like there's a pressure to have the newest thing?

Students: Yes, definitely, 100% yeah.

Students: Yeah. (School A, Interview 1)

In interview one in school A, one of the young people said that they had seen technology change significantly in their own lifetime saying: “The future’s kind of rapidly coming on us” (School A, Interview 1). The young people reported feeling like they did not have a chance to adapt to new technology before a new model came out. This was particularly keenly felt in terms of new models of mobile phones (School A, Interview 1; School B, Interview 3). Specifically, the young people felt that they did not understand the new technology or features in new phones; this turned into a feeling of pressure to keep up (School A, Interview 1). In particular, one young person highlighted how this advancement in technology meant that you would only be able to use the next thing if you ‘kept-up’ with the development of technology (for example, getting the latest phone), but there was a danger of falling behind and not knowing how to use the new devices (School A, Interview 1; School A, Interview 4; School B, Interview 3)

Interviewer:	Do you feel like, like even with phones, you haven't had a chance to understand?
Students:	No, I, there's waterproof phones now. Obviously, we understand what that does, but you need to wait until everyone has one before we can advance again, because before we know it, waterproof phones will be out like, next year or two years' time. Waterproof phones will be something everyone will have.
Interviewer:	Right, so ...
Students:	People buying like new things, and other things will come out.
Interviewer:	Does everybody agree with me, that things are advancing too fast?
Students:	Yeah.
Students:	We're relying so much on technology.
Interviewer:	G–, you look like you're not sure if you agree.
Students:	Yeah, and no. It depends if you have the thing that's just come out, say and a new iPhone's just come out and you got that, but then a new one comes out. You'll understand how to use it, but if you've not had that previous iPhone, well. (School A, Interview 1)

…

Student:	It's most apparent when you say to your parents "Oh, can I get an iPhone seven?" They're like "No, there's no point, because two months later, there's going to be an iPhone eight" and I'm like "Oh, could it just slow down?" (School B, Interview 3)

For these young people, they felt like new technology is moving quickly and they do not understand how new technology works (School A, Interview 1). At least one student seemed concerned that she could not be able to 'keep-up' with advances in technology.

Student (F): I think that a lot of people use computers and digital stuff all the time.

Interviewer: Do you think when you're an adult that you will use it often?

Student (F): I don't know if I can do that?

Interviewer: You don't think you'd want to or you don't think you would know how?

Student(F): I don't think I can stay with like, knowing how to use these 'i'-things and watches and everything. (School A, Interview 5)

While the interviews attempted to focus on how the young people's understanding of the digital world and the digital economy was being shaped by the computing curriculum, these answers came back to concerns the young people had that were not being addressed. Their understanding of the digital world is being shaped by their experiences and social pressures, and a number of these answers seem to raise the concerns that these young people are worried about the speed at which technology is developing.

Specific Concerns about the Digital World.

The pupils had several concerns regarding the digital economy and the broader digital world; these can be grouped in to three categories: usage, privacy, and hacking. Pupils reported that they personally used their devices a great deal but also were concerned about how much 'people' in general used their phones.

Student (M): They'll be texting people that are right next to them.

Student (F): If you're walking next to each other, they'll just be texting each other instead of talking to each other.

Interviewer: Do you think that's a good thing or a bad thing?

Student (M): That's a bad thing because it's un-socialising, because you're not using your [voice].

Student (F): Otherwise, there's not really any point in being right next to each other. You could be on the other side of the world.

(School B, Interview 3)

On one hand, the pupils had self-reported that they use their devices a great deal but they were also concerned about how much people in general will be stuck to their phones in the future (School B, Interview 1; School B, Interview 3). This could have consequences such as deteriorated eyesight, with one young person wondering if "in the future everyone will need glasses?" (School B, Interview 3). Other young people were concerned about the social implications of technology; these young people were sceptical of implications of various new and developing technologies.

Interviewer: All right. Do you think that, what about ...? Using computers like in your car, or in your home to lock things? Would you want to do that?

Students 1: Well, not no, not really. For your home, locking your door whatever, if something goes wrong, that's obviously quite a big mistake because someone could get in. Like there's this thing called Hive, there's that advert, which is like where you can lock your door, you can turn on lights, you can turn off the telly by your phone, but if something goes wrong like communication from a satellite goes wrong and you think you've locked up and you've not. That's going to be quite a big problem.

Interviewer: You think it's a problem because you don't really trust computers.

Students 2: Yeah, something could go wrong at any time.

Students 1: It could work both ways though as well, because if something happens to you while you're in your home, and you've locked it using the phone, then people might not be able to gain access.

Students: Yeah, exactly. (School A, Interview 1)

In terms of privacy, the young people seemed to have accepted that there would be less privacy in the future. There was little sense that this could be changed but that the integration of more devises in the world would inevitably lead to a lack of privacy (School A, Interview 1; School B, Interview). In one of the interviews, they said they felt that this would come through choosing to use more devices such as smart home technology (School A, Interview 1), but in another case, a pupil reflected on story she had read where all people were required to carry a device, meaning an inevitable lack of privacy (School B, Interview 1). They also raised a number of privacy concerns with smart home and Internet of Things technology: "The problem with having a computer in your fridge is it could be listening to you or it could be watching you" (School B, Interview 2).

The young people had started to worry about the implications of many features of their smart phones and had little sense of how secure (or not) their personal and real time information might be: for example, with the concerns that burglars could track a person's phone (School A, Interview 1). While these young people live in a highly digitised and computerised world, they still have an implicit trust in the physical world. For example, wanting to lock a house door using a key versus using a phone (School A, Interview 1).

One of the things that seemed to concern the pupils was the lack of safety built into new technology.

Student (M): The thing is, like I was saying before about technology advancement, it's also becoming very dangerous because the quicker they're trying to make it, the most faults there is coming, the more easier it is to hack, attack. So, the pacemaker you can attack it anywhere ... I mean you could kill a person with a phone if you could-

Student (F): What?

Student (M): Pacemakers are becoming, there is an electronic pacemaker that you can use, and hackers could probably have the ability to change that in a way-

Student (F): Oh, that's weird. (School A, Interview 5)

The pupils mentioned a worry about digital integration in cars, homes, and even the human body (i.e. connected pacemakers) (School A, Interview 1; School A, Interview 5; School B, Interview 2). These pupils did not entirely trust the new technology to not go wrong or be secure.

The discussion showed that the young people had thought a great deal about how technology was advancing but were not being given the opportunity to discuss the advancement in technology—or given the tools to make sense of this advancement—in their computing lessons. Using the terminology introduced in Chapter 3 for the three phases of the digital economy, the students are experiencing and, in some cases, feeling overwhelmed by the technologies of digital economy 2.0. Specifically, the mobile technologies that are advancing quickly and directly impact the young people's lives. They are also anticipating the technologies of the next phase of the digital economy and, as the data shows, are sceptical of how these technologies might impact their lives.

5.2.3 Thinking about their own future and future employment

The computing curriculum sets out to prepare young people for the digital economy and the digital world. Much of the rhetoric prior to the change of curriculum was that the new curriculum would inspire young people to take up careers in Computer Science.

This next section looks at how the young people's choices about the future were influenced by learning computing, before considering if computing was relevant to their futures in general. It then examines their career choices and how relevant ICT skills are to their future careers, and, finally, looks at how some young people have had a negative experience with computing as well as how that has affected their choices.

During the interviews, their career choices and how these choices had been shaped by learning computing were discussed. While many of the students saw the subject as important, the focus on Computer Science also left many pupils feeling like the subject just was not for them.

Interviewer:	What do you think? Do you think you'll need computers for being a nurse, or?
Student 1 (F):	Probably, yeah.
Interviewer:	What do you hope you'll be able to do with a computer as a nurse or hope you don't have to do?
Student 1 (F):	Probably you have to, like, look up information and stuff.
Student 2 (F)	Yeah, I wouldn't mind doing that, I'm just not doing Python and all that again. (School B, Interview 2)

The young people identified a wide range of careers that they were interested in pursuing. While some of these were related to using computers, such as starting an online business (School A, Interview 1), many careers seemed far less related to technology (like becoming a foster carer (School A, Interview 5). However, the discussion about future jobs prompted the young people to consider how computers would affect a wider range of jobs from being a veterinarian (School A, Interview 5) to being a beautician (School A, Interview 4). For example, the pupils who wanted to be beauticians thought they would use a computer to order products and communicate with clients (School A, Interview 4). Many of the pupils saw how IT/ICT skills could be used in a wide range of careers, and that taking ICT at a higher level could be relevant for range of careers (School A, Interview 4; School B, Interview 2; School B, Interview 3).

As in the quotation above, several students expressed that while they thought they would use or have to use computers for certain jobs like being a nurse, they hoped they would not have to do any programming.

Making Choices About the Future.

Most of the students involved in the group interviews were in their final year of Key Stage 3. At this point in the English education system, young people have to make choices about which subjects to continue into their GCSEs and which subjects to cease taking. Several of the pupils felt conflicted as computing is not compulsory beyond year nine (School B, Interview 1). The pupils questioned this; they felt that it was very important to their future careers but to choose computing would be to give up taking something else they might be more interested in.

Student(M): I think it should be compulsory, because then you can still take what you like, then still have the subject.

Interviewer: You find it quite hard because you hear what he says and she says you're going to need it no matter what you do, but if you choose it, it's going to take away from one of the other options that you'd like to follow. Okay.

Student (F): Yeah. If it was mandatory to get one last option, because we … PE is mandatory.

Student (M): I think it should be compulsory because I think most jobs in the future will just be computerised.

Interviewer: You think you'll need it for most jobs. It should be compulsory. Do you think it's more or less important than maths or physics?

Student(F) It's important but my point is like, I don't like it so if it's compulsory, yeah, I'd be fine taking it, but because I don't have to take it, I won't take it.

Interviewer: You won't take it because you don't like it and you'd prefer to spend your time doing something else.

Student(F): Yeah, it might be useful, but I just don't ...

Interviewer: You don't think it's going to be that useful for you, at the end of the day.

Student(F): No.

Student (M): I think it should be compulsory, because online you're going to be doing everything, like bills and stuff, you'd have to always look at that and just for everyday life, things we perform.

(School B, Interview 1)

A number of comments made by the young people related to how computing had had a positive impact on their choice for the future. One student highlighted how, while computing had not changed her long-term plans, she felt there was a large value in continuing to learn computing even at GCSE level:

Student (F): I've always kind of wanted to be an artist, but I didn't really know what I wanted to do for my final option, so I've taken Computer Science because that's better on a CV than quite a lot of the other stuff.

Interviewer: Okay, so even though you want to be an artist, you've kind of gone for Computer Science?

Student (F): Yeah.

Interviewer: Because you think it will give you more options than others? What sort of options do you think it will give you?

Student (F): In quite a lot of universities you need an IT degree to go into the best courses. (School B, Interview 1)

The main focus of the research questions is examining where the young people feel prepared for the digital economy. From these interviews, it seems that the computing curriculum is having an impact on the young people's choices, but this does not necessarily mean they feel they are more likely to choose a career that is part of the digital economy. They are reflecting the skills they might need (in terms of computing) for a wide range of careers.

Is Computing Important to the Future.

The young people seemed unsure if what they were learning in regard to computing was either, giving them skills for the future, or introducing them to possibilities for the future (School A, Interview 5; School B, Interview 2; School C, Interview 1). When discussing computing broadly they seemed to feel that computing was important to their futures.

Interviewer: What do you think of the impact of the computing curriculum is on you? What do you think is the main purpose of you learning computing and about computers in school?

Student 1: To help us in life, when we're older.

Student 2: Yeah.

Student 3: You have extra things that you can do, and more job range.

Interviewer: You know what you're doing when you go into a job.

Student 4: It gives us extra education, no matter what you want to do.

Student 5: There'll be a larger job range as well. (School A, Interview 1)

The workplaces these young people envisioned involved computers in many forms. For example, some young people described using robots in manufacturing (School B, Interview 2). In interview 1 at School C, the pupils brought up the idea of needing to know the "basics" whether this would be just for "most things in life" or if this would be for a specific career such as being a professional 'video gamer' (School A, Interview 2; School A, Interview 5; School C, Interview 1). However, they felt that the speed of the advancement of technology meant that the computing classes could only give them basic skills (School A, Interview 5). In two of the interviews, the young people struggled to think of any activity that would not include the use of computers (School A, Interview 4; School C, Interview 1).

While some felt that the curriculum was generally for life (School A, Interview 1), others felt that the main purpose of computing was specifically about having a future in computing (School A, Interview 2). For these young people, there was a question about computing: are the skills they are learning ‘general skills’ needed for a wide range of careers and life more widely in the same way that every child needs to learn maths, English, and science—or are the skills they are learning in computing for a specific future direction in the way skills they might be learning in design and technology or business studies.

> Student (M): I think it's either there to help you learn and give an idea what it's like for future jobs for what you might want to have for the future in your job lives. Either that, or it just gives you a rough idea of how to use a computer in general and different things like that. (School A, Interview 5)

Skills Needed in Future Employment.

The pupils did have a sense that the purpose of learning computing was the national skills shortage (School B, Interview 2). They were able to see the need to learn programming as not being connected to their needs as individuals but to the needs of the country. This argument left the pupils who were not interested in becoming programmers, feeling less inclined to be engaged in the computing sessions as the purpose of the sessions was to prepare for a career which they had no intention of pursuing (School A, Interview 1). While they felt they needed some skills for life, there were other aspects of computing that were more about preparing specifically for future employment.

> Student(F): It's like you say, you work for life like. When you're older, you don't have the opportunities to go and get help with computers but if you know how to use computers when you're younger, you'll have a better

start in life, which means you get better jobs and stuff. (School A, Interview 5)

The young people could think of a number of careers that would require knowledge of ICT—some of these careers, such as being a teacher, which would not be particularly technical but would require computer use (School B, Interview 1) or careers such as a being a YouTuber which would require "quite a lot of computer knowledge, or editing and that…" (School A, Interview 1). But the young people struggled to think of any job or career where they would not need some knowledge of computing, whether that was using 3d imaging in engineering, or being a rubbish collector (School B, Interview 3).

For some of the young people, this was not an abstract concept. Two of them aspired to work the local power station (where their fathers also worked) so they felt the computing lessons were specifically preparing them for this career (School B, Interview 3). The feeling was that having a broad knowledge of computing would give them a wider range of options in the future (School B, Interview 3), as "most jobs these days, when you do it, they use a computer and stuff like that…" (School C, Interview 1). The young people could see that by learning computing from an early age they would have more opportunities but could also see that it could change the nature of certain fields by increasing the amount of specifically gender diversity in STEM subject which tend to be male dominated.

Student (F): It's going to be a bit of weird tangent one, but I think it's important that we learn because even today, like right now, there is a lot of jobs that require the skills that come from being able to do computing, but also maths and science having been akin to that, because it's like engineering and things like that. I think that it's really important that it's being taught at schools and recently it's been introduced much more in primary schools, hasn't it?

Student (M): Yeah.

Student (F): So, I think that's important because I know a lot of jobs that require things like computers. Like where my dad works, because he works with computers, I've forgotten the title of what it is but it's mainly men. It's really mainly male dominated.

Interviewer: I do agree with that. Do you think that teaching computing in schools will change that?

Student(F): Yeah, because it's making it from a younger age especially with them introducing it into primary schools, it's making a more ... a career path that's much easier for females to enter like engineering and maths and science, using computers, because as we know, the technology is advancing into pretty much everything. (School A, Interview 5)

Specifically, for a number of young women interviewed, learning about computing had introduced them to new possibilities for their futures (School A, Interview 2; School B, Interview 1, School C, Interview).

Negative Experiences.

For the most part, young people felt that learning computing had had a positive or neutral impact on their choices about the future. However, in two of the interviews, pupils related how computing had had a negative impact on their choices. These comments highlighted how a switch from ICT to computing left some young people feeling that they were not able to fully participate in (or did not want to fully engage in) a digital future.

On the whole these comments from young people related to them feeling like computing was complicated or “too complicated”; that all digital devices of the future would require some level of programming skill and that less computerised devices would be preferable (School A, Interview 3; School A, Interview 4; School B, Interview 2,).

As a first example of this perspective, a young woman expressed that she would like to continue to work on the family farm as an adult. However, with regards to computing, when purchasing farm equipment (specifically tractors) she would only purchase one that was not computerised; “I might buy tractors that’s not so complicated” (School A, Interview 3). Similarly, a young person who stated that they wanted to join the Royal Air Force; while they had previously wanted to be a pilot, they were concerned that this would require increased technological skills (School A, Interview 4).

In a separate interview a young person who said they wanted to be veterinarian when asked about career simply said “I won’t be using computers” as a definitive statement (School B, Interview 2).

The final example of a negative change was a young person talking about taking the subject ‘resistant materials’ at GCSE level. This young person stated that they were reluctant to take this subject as they were concerned that it would involve too much 3D design and they would rather be able to manipulate objects directly.

Interviewer: So, have you changed your mind about what you wanted to do? What did you want to do before?

Student 1: I would've gone as a pilot but now we've learnt all this I think you use loads of computers and all buttons it would be a lot different.

Interviewer: So, you want to go into the Royal Air force, but you don't want to be a pilot because you'll think you'll use computers too much.

Student 1: Yeah, I would rather be something else in there

Student 2: It's put me off a bit because I was going to do resisting materials, we still do it but it's too much computers. I can do the visual stuff with the wood and all that.

Student 3: It's now at the point where you make a product 3D print.

(School A, Interview 4)

While these specific young people may have come to similar conclusion when learning ICT, their perceptions of computing means that, as they move forward in life, their view of computing and computers (which they will encounter in many areas of life) has been shaped by the Computer Science focus of their computing lessons.

5.2.4 Conclusion of data regarding digital economy

Not all of the young people had thought about what career they wanted to pursue, and many of the perceptions they had about what skills they thought they would need were influenced more by the skills they saw in their parents than by what they thought the future digital world would be like. From the data, it seems that they can see the need for skills like using specific software (such as office type software). Where they thought that their careers would have a specific technical demand, they could see the connection to the skills they were learning in their computing lessons. For the students who saw themselves in a career that did not directly involved computers, they would rather be learning the general ICT skills rather than learning the more specific computing or Computer Science skills that have dominated much of the computing curriculum (see also Chapter 6).

This section has addressed the extent that young people feel the curriculum is preparing them for the digital economy and digital world. However, the focus on this data is also intended to understand the extent to which the young people are building up an understanding of the digital economy and digital world.

In the interviews, the young people were not thinking of the skills they are learning in terms of the digital economy. Though they are thinking about the skills they will need for the broader digital world, they did not to feel that they are being prepared for this and are left with many questions about how technology is changing society. Their sense of who is involved in the digital economy is limited and this may be affecting the extent to which they feel this is an industry that they might see themselves within.

In terms of the phases of the digital economy proposed in Chapter 3, the young people seem to be thinking about the skills they will need in terms of the skills that would be associated with digital economy 1.0. These are the skills that would be used on a computer at fixed location, but not leveraging newer developments such as big data, open data, or the Internet of Things.

While the young people appear to have an awareness, through their personal experiences, of the technologies associated with digital economy 2.0, this is the area where they have the most specific concerns and questions. Based on the data, the computing curriculum appears to be more rooted in the digital economy 1.0, while the young people experience technology which is based in the digital economy 2.0.

In the following section, the young people's knowledge and understanding of digital literacy will be explored. While there is obviously some overlap between the skills the young people need for the digital economy and digital literacy, an attempt has been made in Section 5.2 to focus on how the young people envision their future engagement in the digital economy, while the next section is focused on how they are already using the skills they are learning.

5.3 Young People and Digital literacy.

This section of the data is focusing on the experiences of the young people by looking at their digital lives, how they are using digital devices in their everyday lives, and what skills they feel they will need to be successful, not just economically in the future but also in general.

The second sub-question of this thesis asks:

2. Do KS3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?

Rather than focusing on the specific term "digital literacy", the data focuses on the skills associated with the term and whether the young people feel they are gaining these skills.

As outlined in Section 3.3.3, this thesis follows a threefold understanding of digital literacy drawn from the literature. The first aspect is that it is fundamentally about using digital tools. The second aspect reflects on the information those tools give one access to, thinking critically about information and content as well as how that information and content have been communicated. Finally, the third aspect is about how one uses digital tools to communicate and connect with others on a social and emotional level. This could be through chat rooms or social media but equally through communal areas such as a comment thread. The social-emotional aspect of digital literacy is about understanding the impact and consequence of one's activity online.

This section focuses on the technical skills (using digital tools), critical thinking, and the social emotional aspects of digital literacy. While there is some discussion of the critical thinking aspects of digital literacy, these are not overtly mentioned in the 2014 computing curriculum and did not feature heavily in the interviews with young people. This is not to say that these skills are not important; it is more likely that they have not explicitly featured in the young people's experiences within their computing lessons. Specifically, it was beyond the scope of the interviews to discuss if they were learning these skills in any other lessons.

This section will first look at the knowledge and skill that young people perceive as necessary to navigate the digital world. In this first part, the discussion focuses on the young people's understanding of why they are learning what they are learning, the things they are learning and value learning, and the things they would like to be learning. This aspect covers the technical and, as far as possible, the critical thinking aspects of digital literacy.

In the second half this section, data regarding the social emotional aspects of digital literacy are explored specifically through their interactions with other people online.

5.3.1 Digital Knowledge and Digital Skills—Cognitive, Critical, and Technical Skills

Digital Literacy

This section looks at what the student see as the purpose of learning computing in general, the aspects of computing that they think they will remember, and then four areas where the young people would like to learn more— ICT based skills, cyber security, hardware and physical computing, and creativity and media. Finally, there is discussion of how the students felt that there is a lack of creativity and media literacy in computing.

One of the consistent themes across a number of interviews is that much of what the young people value as learning, and also want to learn more of, relates to the skills classified as office software such as word processing, spreadsheets, and databases (School A, Interview 1; School A, Interview 2; School A, Interview 3; School A, Interview 4; School A, Interview 5; School B, Interview 1; School B, Interview 2).

Student (M): … I feel this is more of a crash course in computing. We're not doing actual computing because we're not really learning anything. (School B, Interview 2)

Thinking About Using Digital Tools.

Some of the young people felt that they were learning computing to help them in future employment in general (School A, Interview 1; School A, Interview 5), whereas others felt quite strongly that they were mainly learning it to be able to explore a specific computing-based career (School A, Interview 2; School B, Interview 3).

Student 1: I think ICT, it is quite important, but I think it's just going to get more important as the future goes on.

Interviewer: Do you see the difference between ICT and computing?

Student 2: No. (School B, Interview 2)

As the quote above indicates, it could be hard for the pupils to make the distinction between the old ICT curriculum and the computing curriculum. The young people have a very clear expectation that most jobs in the future will involve using computers to a greater or lesser degree:

Students: I think computing's opened up loads of windows, because once again it comes down to what job you want to do, but it has opened up so many windows. Like if you're a businessman, you can solve stuff really easily, and you can communicate with people halfway across the world. I can communicate with my Portuguese cousin, and be in touch with her. (School A, Interview 1)

There is a common opinion that if they are learning about “this stuff” now, they will have the skills to keep up to date with technology; this is especially important as they observe their parents and grandparents ‘falling behind’ (School A, Interview 5).

The pupils are aware of the ICT skills the adults in their lives are using every day, such as email, graphic design, and using the Internet (School A, Interview 2). This helps them imagine how they might use computing in the future. Similarly, because they use the Internet every day, they can see the value in learning how to make a webpage or an online CV (School A, Interview 1).

In the following subsections, the concepts of the skills for the future are used as a way of getting the young people to think about the technical skills they will need to navigate the world of work in the future. While the students seem to find it easy make the link between ICT based skills for the future, they found it more difficult to make the link for the computing-based skills.

Learning Digital literacy - Value What They Have Learned in Regard to ICT.

The young people were asked: “In five years’ time, what do you think you'll remember or use from your computing lessons?"

Many of the young people focused on technical skills associated with using computers. Many of the things that the young people valued learning (and feel they will remember and use in future life) related to using office type software, such as Microsoft (MS) Word, MS Excel, and using databases (School A, Interview 1; School A, Interview 2; School A, Interview 3; School A, Interview 4; School A, Interview 5; School B, Interview 1; School B, Interview 2). Many of the young people reported having learned this in primary school which, for these young people, would have been before the curriculum change (School A, Interview 1; School A, Interview 5; School B, Interview 1). The young people are aware of their parents using these skills, they see the value in using these skills and feel they will remember and use the in the future.

Student (M): Microsoft Office stuff. You'll use that all the time in the future, like power point. Stuff like that. Always.

Interviewer: Always. You'll always be doing ...

Student(M): Yeah, like certain, my mom uses Excel to do how much money she's making, spending, stuff like that.

Interviewer: Do you feel like you're learning enough of those skills now?

Student (M): We did in primary school.

Student (F): Yeah, we did a lot in primary.

Student (M): We don't do that much now. (School B, Interview 1)

It was not directly discussed if the young people are connecting using office type software with the other lessons at school or only with their computing lessons. However, it is interesting that when asked about what they remember, they are specifically thinking about these technical skills, instead of any particular computing concepts.

Some of the young people also valued learning the more ‘computer science’ aspects of the curriculum, particularly regarding logic and learning how it works (School B, Interview 3). This example will be explored in the third section of this chapter focusing on computational thinking (see section 5.4). Other aspects of the curriculum were valued when the young people could relate what they had learned to an everyday example such as using search engines; another child said he got less frustrated when a computer was being slow, because he knew what the computer was trying to do (School C, Interview 1).

Student (M): Well, we had the lesson on searching and that's made me search a lot quicker and understand what things can be saved where. (School B, Interview 3)

As one young person highlighted, the underlying logic of computing is a highly transferable skills and can be used in a range of careers, whether you end up in a career in computing or not (School B, Interview 1).

Four areas arose where the students felt there were topics that were not being covered that they would like to be covered in the computing lessons. They were ICT based skills, cyber security, hardware and physical computing, and creativity and media.

Wanting to Learn More ICT Based Skills.

The pupils felt like they would like to be introduced to a wider range of software and programming environments, and saw computer languages such as Scratch and Python as software environments that they could not apply to their wider lives (School A, Interview 1). The topic of Microsoft Excel came up a number times but, over and over again, the pupils expressed the desire (and, in some cases, the need) to have a better grounding in office type software (School A, Interview 1; A, Interview 2; School A, Interview 4; School B, Interview 1; School B, Interview 2).

Students: If someone for example wanted to be a vet, they'd want to know how to read a computer screen or read an X-ray. You could do that in ICT.

Students: Say if we learnt tips and tricks. So, if you do this it will do this with the computer.

Students: Keyboard shortcuts. (School A, Interview 4)

Again, the theme that repeatedly comes up is that these young people see computers as having a significant role in their future lives, but they would like to be learning 'digital life skills' (School B, Interview 1).

> Student (M): I think just basic life skills, like how to [pay your bills] and I can't think of examples, but I used to ...
>
> Interviewer: Sort of digital life skills.
>
> Student (M): Yeah, just general life skills. How to ...
>
> Student (F): Surveys and that.
>
> Student (M): Insurance and ...
>
> Student (F): How to kill viruses on your computer. (School B, Interview 1)

This is not necessarily to say that they want to have to choose between ICT or Computing. Instead, they cannot see how these two fields are equivalent. Why is it ICT or computing instead of ICT and computing?

> Student (M): We want to learn about IT as well [as computing].
>
> (School A, Interview 2)

5.3.2 Thinking Critically about Content and Information

This section looks at the data that relates closest to the area of critical thinking about content, information as well as hardware. While critical thinking did not come up explicitly, the data raises the issues that the young people are interacting with a wide range of information sources (such as YouTube) but do not feel that they have the skills to judge the validity of this content.

Following on from this, the young people expressed the desire to learn more of the skills that would allow them to engage as content producers on the Internet but, again, they feel that what they are learning in their lessons does not prepare them for this. In fact, they have the feeling that computing is ‘less creative’ than other subjects. In the final section, the young people’s understanding of fixing computers is discussed as well as their perceptions that do not have the skills to fix problems (both hardware and software); something some of the young people think they will need to know.

Wanting to learn more about: Maintenance, Cyber Security, and Trouble Shooting.

These students were aware some of the threats that could cause problems on their computers at home, such as viruses, malware, and hackers, but did not feel they were learning how to keep their computers safe (School A, Interviews 2; School A, Interviews 4). A number of pupils revealed in the interviews that they did not understand how viruses could work (School A, Interview 2), were unsure how to avoid problems for their computers, or how to solve them once they have an issue. These young people are both dependent on computers while at the same time disinterested in how they work (School A, Interview 4).

They are able to find advice online from a range of sources but would like to hear that advice reinforced by what they are learning in school (School A, Interviews 4, 5).

Student (F): And though yeah it always there, like don't give your password and safe posts, but I think we should have something that's a bit more real rather than just going, oh here's a slogan, kids: youth don't do drugs. More like having an actual lesson it. Like password ... Path about password strength and not communicating with people online and things like that. Like having actual active lessons on it rather than it just being a passive message. (School A, Interview 5)

While 'more expert' advice is available, it seems to leave the pupils feeling more confused, or potentially leaves them open to getting cyber security information which is misleading, irrelevant, wrong, or even harmful.

> Student (M): I agree with what M– said because I watched a video the other day by an account called GradeAUnderA,[2] and he basically explained how not to get your account hacked. And he said a lot of good things in there that I've never seen on a poster or heard by my teacher.
> (School A, Interview 5)

While the advice they find on sources like YouTube may not be wrong, it raises a number of questions and concerns about cyber-security. The pupils seemed to have no forum in which to ask those questions. In fact, for many pupils, the group interview itself became an opportunity to get questions answered about cyber-security.

What About Creativity, Logical Reasoning, and Critical Thinking?

Many of the pupils reported engaging on YouTube. The pupils are highly motivated to learn techniques such as green screens (School A, Interview 2). These pupils are surrounded by a rich media environment, with high quality tools easily accessibly; what they are struggling to see is how learning the basics of Computer Science will help them edit a video, create a website, or enter the video game industry. The young people have little knowledge of how what they learn in computing lessons relates to careers in ICT, video game, or media industries.

[2] The video referred to in this quote informs young people of the dangers such as 'sim- swapping' and the need to have unique mobile phone which is only used for two-step-verification.

Interviewer: Okay. Anything else that you wish was covered, isn't covered in computing, but you'd really like to be covered or you'd really like to learn more about computers?

Student 1 (M): Video game development. I'd like to know more about ...

Student 2 (M): Yeah, maybe about what you can do with ICT.

Interviewer: Okay. You mean in the future, so not the skill.

Student 2 (M): Yeah. What ICT can give you. (School B, Interview 2)

In one of the interviews, young people raised the idea that computing felt less creative than other subjects in school (School B, Interview 1). The idea being that in computing there were a set number of logically connected steps:

Student (F): Yeah you just, there not… there's what we do in the lessons, there's not as much room for creativity (School B, Interview 1)

For the pupils, this idea of linked logical steps also meant that if they made mistakes early in the process, these could go undetected until they caused a greater problem later, both in computer programming and also in a student's understanding. They seemed to imply that this need for precision left less room for experimentation and creativity.

Interviewer: Yeah, I know what you mean. Do you feel like it's okay, is it better to, when you're coding something for example, or you're doing something in computing, is it better to get it right the first time, or is it better to make a mistake, and then recognise the mistake and fix it?

Student (M): A little bit of both. If you get it right and you realise that you're right, then you can use that again. If you get it wrong, but if you keep on thinking that it's right, the thing that you got wrong, then that will just completely mess up the thing you're trying to get right. (School B, Interview 3)

While the link between logic and computing was consistent, in at least one case, the students did not feel like this meant there was only one answer, but rather that there are a range of answers in computing. Also, it is interesting that none of the students talk about a creative process of finding the right answer, but rather that it was a logical process.

Student (F): There's more than one answer in ICT because if you're researching something, you can either research it the long way or you can search it using [codes and stuff] and it wouldn't take as long. (School B, Interview 3)

It seemed that this was a new way of thinking for some of the young people, a feeling that one could not take anything for granted: “you've got to run through everything in like a step-by-step, not kind of assume that the computer will know what to do because it doesn’t” (School C, Interview 1).

Knowing How to Fix Things, When it Goes Wrong.

Young people seemed heavily influenced by their parents as to how they approached computers as tools. Some pupils had parents working in the digital industries or were quite comfortable with computers through wide range of office jobs, which require less specialist knowledge and more competence with office-type software. They did enjoy many aspects of the computing curriculum, but they were concerned that they were not getting the skills they might need for their future. However, there is still a degree of magical thinking when comes to getting a computer to work.

Student (F): It's like your computer, right? Switch it on, switch it off. That doesn't work. You long press the on button. That doesn't work. You long press the F9 button. They you press the re-start button. Then you try doing all that again when it's charging, then you leave it for a day and then do it all again, then do it all again, and then bring out the hammer.

Interviewer: L–, where did you learn that sequence?

Student (F): It's a logical sequence that my mum taught me, but if you kind of skip the hammer part. You also need to tell [it] that you're going to take it to the dump. (School B, Interview 2)

It seemed that pupils' attitudes towards computers are changing as computers are no longer the new exciting technology to these pupils. Rather, computers are mundane and everyday, something you need but that still remain, to a certain degree, a black box. Learning to code is no more or less interesting or useful than putting up a shelf; yes, it is a good skill to have but there are always people who can do it for you. It did not seem that the pupils saw learning computing (or coding) as a way of better understanding computers, but as a potentially useful although not necessary skill.

Interviewer: Do you think that knowing a bit about coding, for example, will help you fix it when it breaks?

Student 1: Probably, but I'd probably just take it somewhere to get fixed. (School B, Interview 1)

…

Student 2: It's like a shelf. You either go to Halfords and get your shelf fixed. Or you fix it yourself.

(School B, Interview 1)

The young people desperately want to learn how to maintain their computers. While they are disengaged, pupils cannot see the purpose of what they are learning.

5.3.3 Social-Emotional Literacy

From much of the literature (see Section 3.5), one of the key aspects of digital literacy is centred around the social-emotional skills young people will need to navigate digital social lives and interact with others online.

While the students did not use the language of 'social emotional literacy', what emerged from the interviews was that many of these young people live rich digital lives. Although they did not report learning about navigating these in school, they had thought a great deal about how and why people behaved the way they do online.

This section looks at data relating to how the young people interact with other online, making friends online, how these young people engage with larger communities online, and putting their digital social lives in context.

Interacting with Others Online.

> Student: I admit ...I ...I am different when I'm online, cause online I know people can't see me, people can't hurt me. (School A, interview 2)

All of the group interviews with young people included a discussion of online behaviour both regarding other people as well as the participants' own behaviour. The pupils were prompted to think about how, if at all, their behaviour changed while interacting with others online, and to what extent they thought others changed their behaviour online. The young people repeated many of the messages that are reflected in the popular press about online behaviour; how people can be “meaner” or how negative online behaviour can cause potential consequences (School A, Interview 5; School B, Interview 2; School B, Interview 3). However, there was a great deal of nuance to the young people’s understanding of online behaviour.

In terms of other people’s behaviour being changed in a negative way, there were a couple of different stances taken by the young people. Several of the young people reported a general case that there are people online who can be quite horrible (School A, Interview 5).

> Interviewer: Okay, so the next three things are, I want you to think about the three statements and I want you to think whether they're true for you or you don't think they're true for you. And also, whether you think they're true in general or not true in general. So, the first one is, I am the same person when I am online as I am when I'm offline.
>
> Student (F): I think that's fairly true for me.
>
> Student (M): No…For some people it can be, not all people [though]. A lot of people, we have this discussion before in classes and its people who say like fake who they are, to say impress someone or they start lying about what they are, which it can lead to a lot of things actually. It can lead to bullying; it can lead to all sorts really. (School A, Interview 5)

But there was also an acceptance of some of the reasons why an online presentation may not be completely in line with an offline identity (School A, Interview 5; School B, Interview 3). The young people highlighted that there was a great deal of pressure to look or behave a certain way and while it might not be easy to adhere to this pressure in the physical world, in the digital context it is quite easy to present differently:

Student (M): No, because people would feel under pressure, it's like society nowadays has become more and more pressurised to look either extremely muscly or pretty and things like that. And I guess it's kind of like more or less the same on social medias as well and things like that, because you're pressurised to look like this or else, they feel like they might get picked on or not be cool. (School A, Interview 5)

There was a significant concern with being picked on. There was almost an allowance and acceptance of mean, trolling behaviour online (School A, Interview 5; School B, Interview 2; School B, Interview 3). That people in general would say things online that they would not say in person because there would be few or no consequences (School A, Interview 5; School B, Interview 1). That people in general would say mean things online because they would know they could get away with it. There was even a feeling that some of those who engage in negative behaviour online would either not be 'bad people' in person or at least not say the same sorts of things in person. That in general people would just be meaner online.

Student (F): Like one example I can think of, is people trolling on Twitter. Like, it's just like ... They're saying things that you definitely wouldn't say in real life, and they're probably not bad people in real life, they're just thinking: oh, I'm not going to have deal with any consequences for this, let's be an idiot. (School A, Interview 5)

However, while most of the young people thought there were few consequences for online behaviour, a smaller number actually thought that what effected online behaviour the most was, in fact, that the potential consequences were either social or through formal authority. Whereas with face-to-face interaction people might forget what was said, in an online context “they can scroll back in conversation online” (School A, Interview 5; School B, Interview 1), or there would be proof that one had said what they said.

Even for those who felt that other people behaviour might not change online, there was a feeling that a person’s profile or presentation might not reflect real life either because of exaggeration or the use of photo filters.

> Student (M): I think people don’t always lie; well they just make what they've done sound better than it actually is. (School A, Interview 5)

There was a feeling that it was not so much that people online set out to deceive each other; instead, it was more that the nature of the online environment was to change someone’s behaviour;

> Student (F): Maybe some people change sub-consciously, that we're not trying to be a different person online, they just do it accidentally by ... It's like saying something to get one up on someone or whatever. (School A, Interview 5)

These young people seemed to feel that it was inevitable, to some extent, that online environments represented a different set of behaviours and that many people took this as an excuse to engage in negative behaviour.

Making Friends Online.

Student (M): I'm really sad saying this, but one of my best friends I've never met. I've never told any of my details other than what my username is on what I play, but I think he can never judge me because he's never going to see me, he's never going-

Interviewer: So, you feel like you can be more honest with him?

Student (M) 2: Well that can be quite dangerous though?

Student (F): Yeah, because the way that E– is doing it that's safe and he knows, and he knows what he can and can't do and what he needs to do to make sure that he's safe. And then we mostly talk about the bad things and the things that could go wrong and not talk about the ways it could benefit here. You could, like A–said, A–'s got this best friend online and say he's had a really bad day and no one else understands and no one is there for him and he feels like he can speak to this friend and he doesn't have to give anything about himself away, he can just be himself. (School A, Interview 5).

Several young people reported using the Internet to maintain connections with friends and relations across the globe, or with friends whom they knew through other contexts such as a previous school (School A, Interview 2).

The pupils reported having connections with people in San Francisco, the Philippines, Kent, France, and Portugal (School A, Interview 1; School B, Interview 1). In some cases, these were maintaining relationships with family, but in some cases (as demonstrated from the excerpt above), these are individuals who the students have met through online activities. Equally, other pupils reported that they used social media to engage with pupils who did go to the same school but with whom they would not normally interact (School A, Interview 3). The pupils demonstrated a benefit from these relationships, from close friendships to being able to practice language skills to maintaining family contacts. The pupils did not feel at risk from these relationships; in fact, they felt that they knew what precautions to take and were very conscience of dangers (School A, Interview 2; School A, Interview 5).

Part of Something Bigger.

As well as making connections with people all over the world, young people are also using the digital networks to feel like they are part of a bigger community. While many of the young people did not report being part of any online groups, in one interview they reported that they were part of a "guild" or group within a game (School B, Interview 1). In a second interview, it was reported that these groups were enough for the young people to explore their interests and develop a sense of belonging.

Student (F): I take part in this simulation thing, and as a community, loads of people join. We join as in pilots; air traffic controllers and we all work together to make it happen. In a real-life situation.

Interviewer: So, like an airport simulation?

Student (F): Yeah but we do it and if there are any signs of bullying, there are administrators on 24 hours a day. (School A, Interview 5)

In the example above, we can see that that the young woman has found a way to pursue a relatively niche ambition of becoming an air traffic controller. She feels safe because of the infrastructure of the simulation, but also has a sense of being part of a greater task. It would potentially be quite difficult for a teenage girl to find be able to connect with other people as passionate about airplane and specifically control tower operations; however, this activity allows her to explore a potential career, hobby, and passion.

By contrast, another young woman, who spoke of wanting to be a politically active in later life, said:

> Student (F): I don't talk to people I don't know. I am part of the youth feminist army, I'm part of that but I don't talk to anyone from it. I'm just part of it as a movement, but that ... I'm part of groups but I don't talk to people. (School A, Interview 5)

While being an observer may be her best way of engaging in this group, as she gets older, she may want to engage in more interactive way. However, without clear guidance it is unclear if she would feel she had the skills to confidence to engage in this or similarly politically engaged groups.

Digital Social Lives in Context.

While it is easy to have a sense that young people are living their digital lives with little sense of the past or future, it seemed that in fact these young people had a feeling of how the digital world was changing around them;

> Student (M): Can I just say I don't think trolling is what it used to be. Now it's just something like hate basically. (School A, Interview 5)

The young people could see that while at some point the concept of ‘trolling’ had seemed innocent, as much as anything an online practical joke. These activities were being taken more seriously and were having serious effects in the real world.

They were also are aware of the impact of social media and a social media history on other adults:

> Interviewer: Do you think how you behave on social media will affect your ability to get a job in the future, or should it?
>
> Students: Yes.
>
> Students: Definitely.
>
> Interviewer: Do you think it should, or do you think it will?
>
> Students: Well, it depends on if your profile's private, because if your profile's private, you can't see ... Like, your business can't see what you're saying. Like my mom had a colleague who put something on Facebook about the school. She works at a school, and she got fired because it was a bad comment about the school and she got fired because she put it on Facebook, so. (School A, Interview 1)

These young people are not viewing social media as a sharing platform; rather, they see the role of social media as a place to have a profile and communicate with peers. The chat environment can be quite informal, an extension of their face-to-face networks. They appreciate that the more public online performances will not necessarily reflect on offline reality for many digital networks are their chance to explore hobbies and make new friends.

5.3.4 Living Digital Lives—Conclusion Regarding "Digital Literacy"

The young people interviewed for this thesis live in a world surrounded by digital devices. As such, these young people have a thirst to learn more about how these devices work, how to fix and maintain these devices, and how to use these tools to their maximum effects. While some of the young people are engaged in a curriculum more focused on Computer Science, many see it as disconnected to their future lives and feel a loss at no longer learning how to use the software packages that they see the adults in their lives using every day. They are very aware that the way they use computers in their own lives could be very different to how they will use computers in their future lives. Rather than preparing the young people for the future, the focus on Computer Science leaves the pupils with a feeling that computers are difficult to program and hard to fix and that they are not getting the computer skills they would need for a career other than computing. These young people lead rich digital lives and do not make a clear distinction between an 'online' and 'offline' world.

Coming back to the research question:

2. Do KS3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?

It does not appear that from the pupils' perspectives that their digital literacy needs are being met. The curriculum is not digital literacy focused and much of the move away from the ICT to computing was to focus more on concepts rather than skills. The literature covered in this thesis (in chapters 2 and 3) demonstrates that digital literacy remains a key skill for young people to learn and the 2014 curriculum states that young people should learn to be digitally literate.

Using the three-fold understanding of digital literacy, and firstly regarding the technical aspects of digital literacy (how to use technology better), the pupils do not feel they are learning many of the technical skills they might need to navigate a future digital world but are aware of these skills and want to learn them.

Regarding the critical thinking aspects of digital literacy, while pupils did not expressly assert needing to learn these skills, they demonstrated the importance of these skills through the discussion. They also communicated a desire to be part of a community of content creators on the Internet. They had a feeling that computing was not creative, or an area for creative expression.

In terms of social and emotional skills, pupils do not seem to expect formal education to teach them the skills they need. However, they do seem to be leading rich and complex digital lives. If the curriculum is aiming for pupils to be digital literate, there is a role for including more material on how to behave online. While the students are engaging with digital media broadly, they have not thought deeply about the critical literacy skills needed to consume this media as a 'critical consumer'.

5.4 Computational Thinking

One of the main criticisms of the ICT curriculum prior to the 2014 reforms was that it focused too heavily on the use of specific software with not enough emphasis of Computer Science and how computers work. Specifically, the curriculum calls for students to know what computational thinking is and how to apply it (DfE, 2013).

The third sub-question asks:

3. What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?

In Section 3.4, this thesis explored the area of 'computational thinking' in literature, examining the connections between computational thinking, Computer Science and programming, and identifying three approaches to computational thinking: the general problem-solving approach, the computational model approach, and the programming approach.

In the following section, the students' knowledge of computational thinking, Computer Science and programming will be explored, and also the use of computational thinking as a general problem-solving skill. As shall be seen, the students have little reference for the term 'computational thinking' in general. While there are a range of terms and concepts that are associated with the topic, these are only raised within the data to the extent that the young people did (or did not) bring them up.

5.4.1 Computational Thinking, A General Problem-Solving Skill?

A great deal of emphasis has been put on the importance of young people learning computational thinking. While the definition of computational thinking is varied (see Section 3.4), the next section of data looks at whether the young people had an understanding of what computational thinking is, but also if they felt they could apply it. For a number of the students, the interview was the first time they had come across the term "computational thinking" and they put forward a range of definitions. It should be emphasised that this did not reflect any conclusions about the quality of teaching at any of the schools but rather how different schools choose to place different emphasis within the computing sessions.

This section is specifically exploring computational thinking as a general problem-solving skill rather than a skill associated with either a fundamental understanding of Computer Science or a knowledge of programming.

Even within computational thinking, when the pupils built up an understanding of a specific concept (in the following example, 'algorithms'), the concept had been abstracted to such an extent that they were unable to relate it to their experience of using technology. For those students who had no plans of continuing to study Computer Science beyond the statutory level, these abstracted concepts held little value as technology already would have them “built in”:

Interviewer: You don't use any algorithms at home. You sure?

Student 1 (F): Well, I probably do, just without noticing. Well like, make the coffee or tea, or that’s an algorithm but not an electronic one

Student (M): If you're like "I bake a lot of food at home," that's got algorithms in it because it's got steps.

Interviewer: Baking is a really good example of an algorithm, actually.

Student 2 (F): We do use them at home, but it's not ones where you have to make them up and then you have to put them on the computer and test them to see if they run. It does help you understand things like that.

Student 1 (F): Because if you were doing electronical algorithms, you don't really need to do them because they're already kind of built into your phone from when they were made.

Interviewer: Some of them are.

Student 1 (F): Just the main ones, like if you press the button, it'll come on. (School B, Interview 3)

What is Computational Thinking.

Every group was asked if they had heard of 'computational thinking'; in only 2 (out of the 9) groups interviews did pupils answer affirmatively that they had heard of the term. Even in the case where the students were aware of the term, none of the students felt confident about what it might be but rather offered a range of answers about what they thought it might be. While many of the answers could align with some of the concepts of computational thinking, for the most part, they involved a combination of the following ideas:

1) Thinking logically (School A, Interview 5; School C, Interview 1)

2) How you think when you use a computer or thinking with a computer (School A, Interview 4; School B, Interview 3)

3) Thinking like a computer or in a kind of computer code (School A, Interview 1; School A, Interview 2; School A, Interview 3; School A, Interview 5; School B, Interview 1; School B, Interview 2)

> Student (M): Thinking in like a way something like in a computer. Thinking in like computer like way
>
> Student 1(M): thinking logical like a Vulcan (School A, Interview 2)

These answers align fairly well with the three dominant understandings of computational thinking: the first answer aligns with the computational model approach, the second aligns with the programming approach, and the third aligns with the general problem-solving approach.

While these answers align fairly well with different aspects of computational thinking discourse, they also all highlight different aspects of the topic. Some students (School A, Interview 3) also thought computational thinking might be just the process of thinking about computers. While other thought it might be "how a computer thinks":

Interviewer:	What do you think it might mean?
Student (F):	What do you think?
Student (M):	Computer scientists and what they would think about how they would think about how to make programs and their way of thinking about it.
Interviewer:	Computer scientist?
Student (M):	And how also it could be the ... How a computer works. So, say like you've made the programming, and you've written in an algorithm and it's how the computer makes it work.
Interviewer:	Any other guesses?
Student (F):	I want to say if you think like a computer, it's really logical thinking right up there. (School A, Interview 5)

…

Interviewer:	What do you think it might mean?
Students:	Thinking with a computer.
Interviewer	Thinking with a computer, okay.
Students:	Where you've got one program sorting one thing and the other program sorting another thing and then it all links up together.
Students:	Maybe thinking like a computer.
	(School A, Interview 4)

What seems to come through these answers is that the students attribute a degree of autonomy and agency to the computers themselves; they feel that computers do “think”. Rather than this being connected to the term ‘computational thinking’, it is more related to the young people’s experiences of computers acting in unexpected ways which can also be seen in section 5.3.1 where a young person referred to threatening the computer (School B, Interview 2).

Using Computational Thinking in Other Areas.

While these young people did not recognise the words ‘computational thinking’, upon reflection they were able to see that computing was giving them skills they were able to apply in other parts of life even if it was merely improving their concentration (School B, Interview 1). Once they had been introduced to the idea of computational thinking, it seemed like it might be something useful that would help them better understand how computers solve problems (School A, Interview 1).

As one young person highlighted, the use of logical thinking was probably more important than learning the logic of computing, at least for those who did not want to pursue a career in computing.

> Interviewer: Do you think the logic is more important, or do you think the other stuff is more important? Or are you not sure?
>
> Student (F): I think the logic is important in life, but if you want to have a career with computing, then it's just as important as each other. (School B, Interview 1)

One of the differences the young people seemed to identify between a subject like maths and computing was the need to be able to work out the right answers out of your own mind. While there were a number of ways to answer a question, it was hard to know which subset of answers were correct and it required a process of elimination to get the right answer.

Interviewer: Do you feel like your computing classes require you to think in a different way.

Student 1 (F): Yeah.

Student 2 (F): Yeah.

Student (M): Yeah.

Student 2 (F): Because when you do maths and stuff, it's more like you've got something to work on, like a piece of paper, but when you do it in ICT, you have to work it out in your head and then show it on the computer, but you can't write it down and stuff. We actually have a piece of paper, but we don't, really. We actually have to work it out in our heads.

Student 3 (F): In maths, you have the knowledge in your head. You have all the numbers and everything, so it's almost like you're plucking different things out of your brain and then you just add them together and then you write it down, but in ICT, I know less stuff than I do in maths, so it's almost like I'm trying to build up a new subject in my head, almost.

Speaker 2: What does everybody else think?

Student 2 (F): In maths, there's always one answer and you can either get it right or wrong, but in computers, there's not always one answer. There's several different ways that you can make it right.

Student (M): In ICT, it's more process of elimination instead of working something out. (School B, Interview 3)

The pupils were aware that computing was giving them new tools to solve problems in the world. These intellectual tools felt new to the pupils, but they also could see the value. What the students did seem to have found was that this new way of thinking had not been taught to them explicitly; rather they had become aware of this new way thinking themselves.

What Makes You Good at Computational Thinking?

The impressions of computing not only gave the young people a sense of what computational thinking is, but also what sort of person might be good at computing. One of the difficulties with a subject such as computing is that, while there are skills that are associated with doing well in the subject, these skills can reinforce stereotypes of the type of people that subject is for. While some students felt that they might be becoming more logical or patient from taking computing, this seems to indicate that they are conforming to the stereotype rather than seeing other ways to excel in it (such as relating to creativity).

Familiarity with computers and technology led to developing computational thinking skills that was new way of problem solving.

Interviewer: This is a question that's not on your sheet but what sort of person do you think is good at computing or good with computers?

Student (F): [someone who is good at] maths and science.

Interviewer: Okay.

Student (F): G [male]

Interviewer: What do you mean by that?

Student (F): He's good at maths so ... Maths isn't fun.

Interviewer: Somebody who's good at maths. Any other ideas? Any other things about people who are good at computing?

Student (M): Not old, generally, relatively. They're not grandmas and granddads are not that good at technology.

Interviewer: Right. Do you think that would be the same, so that when your older you won't to be as good as the people who are younger?

Student (M): Yeah, I think we might be because we grew up with technology, but they didn't grow up with it.

Interviewer: It's not about the age it's about growing up with it.

Student (M): Yeah.

Student (F): You need to be quite good at understanding stuff like [logic]

Interviewer: Is that the same as maths?

Student (F): Not really. There's more problem solving.

(School B, Interview 1)

As much as anything, computational thinking was about seeing patterns. Someone who is good at computational thinking would be good at maths and able to see patterns and concentrate on details.

Student 1(F): You definitely have to be quite good at maths.

Student (M): Someone who can see patterns.

Interviewer: Yeah. Any others?

Student 2(F): You have to be able to concentrate a lot. [look around what different things are] (School B, Interview 3)

For other students, to excel in computing, a person would need to think logically, be smart, patient, and observant to spot errors (School C, Interview 1). The pupils could see that computing was helping them become better problem solvers and get better at concentration. But they also found that, as they used computers, they thought more how the computer was working.

> Student (F): When I use the computer, I think about it more, like I think about what's behind (School B, Interview 1)

In another groups of students, they felt that computing had not changed how they thought either because they already thought in a way that was compatible with computing or they felt that they never would be.

> Interviewer: So, it doesn't change you? You don't think differently, or problem solve differently?
>
> Student (M): No, because computing is how I probably solve the [problem].
>
> Student (F): The beginning of everything. (School B, Interview 2)

Coming back to the research question:

3. What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?

From the data presented here, it seems that young people do not have a clear understanding of what computational thinking is. Few were able to say “this is what we were taught computational thinking is”, although they were able to put forward guesses as to a range of definitions. Interestingly, the answers the young people came up with within the interviews matched the definitions covered in Chapter 3. However, some young people thought the term referred to how “computers think” rather than thinking about or with computers themselves.

Some of the young people could see the value of learning to solve problems more logically and being able learn new ways of thinking. However, the pupils also seemed to think that a certain kind of person would be particularly good with computers and good at computational thinking. While some of this had to do with familiarity with technology, it also seemed to do with being a certain kind of person.

Returning to the three approaches to computational thinking — the general problem-solving approach, the computational model approach, and the programming approach — it seems that there is little clarity as to which form of computational thinking is being applied. The young people are learning concepts related to each approach, but without context. In terms of the general problem-solving approach, the pupils seem to be building up a degree of appreciation regarding how to apply computing logic (logical thinking) to other situations, but this seems to be the type of computational thinking that is being taught the least directly. In terms of both the computational model and programming approach, the pupils are being taught specific aspects of Computer Science (and computation) and programming; they are not being taught computational thinking.

5.4.2 An Understanding of Computer Science and the Computational Approach to Computational Thinking

Much of the computing curriculum relates specifically to theoretical and practical aspects of Computer Science (such as learning multiple computer languages, understanding binary logic, and understanding how hardware and software work). The young people mostly felt that these Computer Science aspects of computing related to specific careers but were less relevant to people who might not choose those careers. In some cases, they felt that they might need to know about how "computers work" (School B, Interview 3), but this was a distinction that not all of the students could make:

> Interviewer: When you're an adult, how important do you think it's going to be to understand how computers and software work?
>
> Student (F): If you had a job to do with computers, it'll be important to know how they work.
>
> Student(F): Because of how we discussed when we felt that programs and stuff was going to advance, I think it will probably be quite important because it's going to be more to do with electronics and programming and stuff. In the future, I think it's going to be really important for us to know about computing.
> (School B, Interview 3)

Other young people though felt that, while it was important to know how computers and software work, for many jobs, they were not getting the right preparation (School B, Interview 2). The young people also raised the questions of how much society in general would need them to have the skills they were learning; that even if they were not super excited by learning to write programs, it was important that they were learning these skills.

> Student(F): I think what M– was talking about before, the technology coming into everyday things like life, they're going to need more people to be able to know how to make that stuff, and you're going to have to know how to use that stuff. So, it is going to get bigger and you're going to have to know and it's

important, because that's going to be a big part of your life in the future. (School A, Interview 5)

Computer Science Valuable or Pointless?

Student (F): I don't see how any of us here will end up in a position where we will need to manually work out what the last digit of a bar code should be.

Interviewer: Don't you find it interesting, though?

Student (F): It was insanely boring. It was mind numbing. (School B, Interview 1)

Some students were able to see the value of these more technical aspects of the computing curriculum while others felt it was relatively pointless, and there were a few comments that express that, while it was interesting, they could not see the value in the subject. One of the recurring themes of the interviews across the various themes was that the students could see some aspect of the value of the broader subject of computing (why it was important, that it was relevant to later in life, etc.) but were not able to connect this overarching view to the specifics of what they were learning.

Interviewer: Yeah? Okay. Thinking about the future for a little bit, when you're an adult, how important do you think it will be to understand how computers and software work, and this is something we talked about a little bit earlier, as well.

Student (M): It's really quite important, because the world's moving towards more of a digital age, so it's quite important to understand that, just how to use stuff and how to connect with other people.

Interviewer: Do you think it will change your ability to use it, or do you think it will just be helpful to know how things work?

Student (M): It will probably just be helpful. (School B, Interview 1)

Even within the same interview, some of the students could see that understanding how computers work would be valuable (in the abstract) while others felt that if they ever needed this knowledge, they would be able to find it at a later date.

Interviewer: When you're an adult how important do you think it will be to understand how computers work?

Students: not very

Students: very important

Students: ‘cause there will be something better than google

Students: I think it's going to be very important because we will rely on it.

Interviewer: You'll think you'll rely on it? Why don't you think it's important?

Students: Because you just google it don't you?

Interviewer: You can just find it out so there's no need to know it.

Students: Then again when it comes to exams you cannot use it. (School A, Interview 4)

Similarly, when discussing learning binary (School A, Interview 1), some students could see how this related to an understanding of how computers work whereas others could not. Some students felt like they had learned a basic level in school and then were able to build on that knowledge at a later date (School A, Interview 5). In this example, formal education was able to provide foundation from which the pupil could build.

Broadly, many of the students struggled to see how what they were learning in class would relate to how they currently use computers or would use computers in future. While computers play an important part in their lives, computing as a subject in school was very different from using computers at home or how they imagined using computers in the future (School A, Interview 1). Others saw it as either interesting but not really useful or not really have having relevance to their lives. The pupils connected this to specific topics with a more explicit Computer Science aspect (such as binary and cyber security) (School B, Interview 1, School B, Interview 2).

Even when the young people had more complex programming projects to work with, they struggled to see how these related to the "workings of a computer":

> Student (M): If we were to like, if we were to learn about the inside of the computer, how to [open it], how a computer is built, how everything gets displayed on the screen. The coding between the mouse and the thing, I don't need to know how to create a Magic 8-Ball in code.
>
> Student (F): And then like we don't change to do anything else. We haven't done like, anything more interesting that, than we've been doing. Because in Year Seven, we were doing the same things. (School A, Interview 2)

Some of what they valued learning is related to the logic of Computer Science and computational thinking (School B, Interview 1; School B, Interview 3; School C, Interview 1) and what they find most frustrating is the actual process of coding (School A, Interview 1; School A, Interview 4; School B, Interview 1; School B, Interview 2.)

Things About Computer Science They Wanted to Learn More About.

One of the discussions areas centred around what the students thought they should be learning and what the students thought would make the lessons more engaging. As such, these discussions raised a variety of answers across a range of topics. In school A, every group brought up topics connected to other aspects of Computer Science which they felt were not being addressed. What also arose out of several answers from these groups was that the pupils did not feel they had gained an independent competence with the topics covered. While they had learned, for example, how to create a binary calculator, they did not feel that they sufficiently understood the underlying principles involved:

Interviewer:	But do you feel like you wouldn't know how to start if you're trying to do your own project?
Student 1 (M):	Yeah.
Student 2 (M):	You could always teach yourself stuff.
Student 1 (M):	Say somebody was to put a computer in front of me and go make me a binary to denary calculator I would go, I just wouldn't know what I'm doing.
Interviewer:	Okay.
Student (M):	I would not know where to start even after two years, I know (School A, Interview 2)

What other pupils felt they were missing was a sense of how what they were doing fitted into a broader context. While they were learning how to do specific aspects of a program, they were not building up the understanding of how that related to an 'advanced' scale; that is, how does what they are learning relate to a broader understanding of entering a career in computing?

Student (M):	Different ways of giving ideas to people, I guess. Some say you could use programs to show how cool and different things you could end up doing at an advanced scale, so the higher-class things you could make instead of going just straight and saying right, okay, just write these words here and it will show you some numbers. Because people actually want to see things that will keep them interested and will keep them excited for the things.
Interviewer:	Do you mean like seeing the end result or seeing what you can do?
Student (M):	Seeing what things your teacher showing you about how advanced it could get and things like that. (School A, Interview 5)

But the main aspect (which has been discussed previously) is that, in a number of interviews (School A, Interviews 1, 2, 3, & 4), the young people wanted an understanding of how computers work on a physical level. Some students expressed this as wanting to learn more about the 'engineering' (School A, Interview 2) aspect of computing, or how technology worked:

Students: How different technology works, like phones and things. We're learning about computers, so because I think phones, they work on the same like, binary, but it's different, because they give you different things like in a touch screen, and then like different apps. (School A, Interview 1)

Some students felt there was not a practical element to the computing lessons, such as when one group remembered a lesson where they had previously "opened up a computer" (School A, Interview 2). This desire seemed to relate partly to feeling the current approach was too abstract, or a practical nature for wanting to learn about how computer work; as one student put it, they wanted to learn "…how to fix your laptop if it goes wrong" (School A, Interview 3):

Interview: So how to use [computers] more than how to program?

Students: Things like how a computer's put together.

Students: practical and physical things

Students: Building computers, taking them apart.

(School A, Interview 4)

These young people are interested in computing; they want to know how computers work, but struggle to see how what they are learning in computing relates to this. There are many aspects of computing and Computer Science that the young people are interested in; however, what they lack is an understanding of what Computer Science is and the purpose of the computing sessions.

Computing as a subject is complex in that, while it relates to the academic discipline of "computer science", it claims to be broader than this, and young people do not really have sense of what this 'broader' Computer Science might be.

5.4.3 What About Programming and the Programming Approach to Computational Thinking

Programming has become central to the computing lessons. For the young people, programming presents a number of challenges. Many of the young people find it difficult to learn, hard to relate it to either how they will use computers in the future or how they use computers in their lives, and why they are learning it. The following section looks at how the young people themselves reflect on learning to program.

Learning to Program.

A number of pupils reported that they did use code outside of lessons (School A, Interview 1; School A, Interview 3; School A, Interview 5; School B, Interview 2). Specifically, a small number of boys said that they had used programming in their spare time and those students felt that they had been able to build on what they had learned in lessons:

> Student (M): Well I've used a lot the stuff I've learned in class because I've built a PC and we learned about how to build a PC in Year 8. I've programmed some stuff, which we learned how to do in school although I did it more advanced, I still knew the basics. (School A, Interview 5)

One young person remarked that he had been able to get help from a parent that works with computers for living (School A, Interview 5). All these individuals talked of using the programming language Python (which they had learned in school) at home. This seems to make the argument that learning to program gives opportunities for young people to pursue computing to a deeper level in their free time. On the other hand, it could also be argued that these were all students who would have been interested in computing anyway and, while learning to program in school had helped them, they would have in fact explored this skill with or without the support of the school.

In another interview (School B, Interview 2), two of the boys said they had tried to learn to program on their own but that the teacher's instructions made it much easier to understand and the discipline of the school environment made it easier to stick with it.

> Interviewer: B–, you know a lot about computers already. Have you learned any other languages or done any programming on your own?
>
> Student 1 (M): I always try to. I just find it hard to focus on it and just continue to do it.
>
> Interviewer: It is a hard thing to teach yourself usually.
>
> Student 1 (M): Yeah. It makes it easier in school and stuff to learn things like Python.
>
> Student 2 (M): The teachers definitely make it easier to understand it. (School B, Interview 2)

From the same interview (School B, Interview 2) the young people did feel limited by the programming languages that were being taught in school (generally just Python), questioning whether this was the most relevant language to follow a career in computing (School A, Interview 5; School B, Interview 2).

Interviewer: Do you think what you've learned so far about Computer Science helps you or do you think it's just so far beyond it that it just ...

Student 1(M): I don't know that it helps us.

Student 2 (M): I feel I guess outdated because Python isn't really that used as much. I'm not aware of it being used that much anyway. Something like Java Script or something along those lines. (School B, Interview 2)

While the young people could understand that 'programming' was a career and could see that learning to program could relate to this specific career, they were also wondering if other skills relating to computing might be more useful more applicable to wider range of career choices. Another young person put it simply when asked if they would use programming in the future, "Maybe twice in my life" (School A, Interview 3). On the other hand, other students felt that while learning to program was interesting it would not be useful in the long run. Students compared learning to code to learning maths; both are important and while each is useful in some fields, they may be useful to a greater or lesser degree in different situations (School A, Interview 1).

Students: I think learning Python and stuff, it's just more of like interest, like learning how a computer works. I don't think it will be that necessary for later on. Just more curiosity than anything else. (School A, Interview 1).

Do You Think Programming is Useful?

There was a broader question, of whether or not the young people said they used programming either at present or would use it in the future. There was also a question of whether the young people thought that programming was something that was useful to learn. For example, one young person related specifically that they were able to build on what they had learned in school to fix something on their computer.

> Student (M): [knowing Python] helped me fix the script on the computer.
>
> Interviewer: What script was that?
>
> Student (M): I was using a program called Hydra, and it went wrong, and I had to fix it.
>
> Interviewer: Okay.
>
> Student (M): There was a tutorial on YouTube, and it did help that.
>
> Interviewer: Yeah, because you've done a little bit, so something had gone wrong in using ... And did you feel like you wouldn't have necessarily understood that YouTube video, if you haven't had to?
>
> Student (M): Yeah. (School A, Interview 3)

Again, it is unclear if the young people would have been able to do this without learning computing in school or if having learned to program in school just made the process easier.

In one of the interviews (School A, Interview 1), the young people did feel they would remember how to code in the future even if it was at a basic level. They thought they would remember "simple codes" (School A, Interview 1) which could mean that, even if they could not envision using programming in the future, the option to use it would remain. Whether they thought they would use it was another story. While some felt that they would only use programming if it was relevant to their jobs, others thought that it could be useful in order to solve problems with a computer:

> Students: I think it's because if in like future, it's going to change with like computers. If you've a computer breaks, you'll actually know how to fix it, and-
>
> Students: Yeah and know what's gone wrong. (School A, Interview 1)

In this same interview when one of the young people said, “we’ll really have to use Python *everyday*” ([emphasis added]; School A, Interview 1), the statement was met with giggles.

In other groups, they felt that, while learning to program in general could be useful, the projects they were doing did not relate to the real world and they struggled to see how they would use programming in the future. They wondered if they were learning to make ‘apps’ they might be able to relate to their lives and how they would use programming in the future (School A, Interview 1; School C, Interview 1). The young people could see how learning to program could relate to a job as a programmer or Web developer (School A, Interview 1), and being able to program could lead to a ‘better’ job:

> Interviewer: So, to what extent do you think what you've learned in computing classes, relates to how you use computers in your everyday life or how you will use computer in the future.
>
> Student(M): Well Python again, programming is a career job when older, there is programming websites and things like that making your own computer systems and that, that's what things like Python's for. Whereas other things we use could again lead you to better jobs like what M– was saying because a lot of jobs you need-

Interviewer: Do you think that what you've learned in your computing classes relates to how you use computers?

Student(M): Not all the time. Sometimes but not all the time.

(School A, Interview 5)

Do You Enjoy Programming?

Secondary level education young people often move from using block-based programming environments (such as Scratch) to using text-based programming. A number of the young people found this transition difficult (School B, Interview 1; School B, Interview 3). There were a number of aspects of Scratch that the young people found enjoyable; they found that it was a more friendly environment because it was more colourful and included a 'cat' animation by default (School B, Interview 1). However, what was more useful to the young people was that Scratch is more 'graphical' and it was an easier environment to see how the program was operating.

Interviewer: You prefer something like Scratch to something like, I don't know, Python. I don't know if you guys, have you done Python?

Student (M): Yeah.

Student (F): Just typing out line after line after line is, with Scratch it's easier to see where you've gone wrong.

Interviewer: Right.

Student (M): Yeah, something that Python could make maybe more engaging is if it was more colourful.

Interviewer: More colourful, okay.

Student (M): Yeah, it’s more rewarding in Scratch. And more graphical. You can see exactly what you're doing when you click the playback.

Student (F): And Scratch has that cute little cat. (School B, Interview 1)

This aspect of feedback came up again when discussing programming Lego robots. When the young people input the code, they could immediately see what was happening.

Student (M): I just like when you code stuff, but then it's like, with the robots you can see what your code is doing.

Student (M): Oh yeah. You can see the results.

Student (F): Yeah, if you code something you know it.

Interviewer: You know right away if it's working because it moves. (School B, Interview 1)

It seems that, for these young people, programming in a text-based environment is abstract because it is harder to understand what is happening. Without either graphic or physical feedback system, they do not enjoy the experience of writing the program as much. While Python is a common language for schools to use to teach text-based programming, something that allows for more immediate feedback could be more engaging for the young people. From the interviews, it seems that there is a difficult balance to achieve when it comes to teaching programming. The young people need to be able to see how programming is relevant to their future, but it also has to be engaging in the moment. The challenge is that the curriculum requires that the young people learn a text-based programming language that not all the young people may find it easy to engage with, especially with a programming language like Python which has a less engaging interface.

Frustrating for Some Students Wanting More?

As previously mentioned, some of the young people found it easier to learn to code in school as opposed to teaching themselves at home (School B, Interview 2). However, others found that it was just confusing when the teacher tried to demonstrate the code. This highlights one of the apparent contradictions of the programming aspects of the computing curriculum: while some students find it hard to engage in the lessons, others wanted more depth and found this lack of depth equally frustrating.

> Student (M): More programming stuff where they… I guess these guys probably wouldn't agree, but I would prefer to learn a lot more along the lines of writing code and compiling it.
>
> Student (F): We already have and it's just boring.
>
> Student (M): Yeah, but we haven't though. We literally, all we've done is learn the print command and a couple of commands that let us ask questions and stuff. That's all we ever have done in terms of computing. (School B, Interview 2)
>
> …
>
> Student (M): …I want to learn more. I feel like we just dip into Python and then it's like, "Well, that's the program. Let's go on to something else now because we're not really doing anything with the program." (School B, Interview 2)

In this interview the student who was most engaged in computing appreciated the computing lessons but did not feel he was being served by the structure of the content.

Compared to an interview in another school (School A, Interview 2) the student felt that they were spending too much time on a single program (Python) and would have liked more variety as they felt they were going over the same content over and over again, insinuating that learning different commands in Python was repetitive.

> Student (M): You'll learn one thing in the first year and then you'll do the same thing the next year and the next year and the next year and the next year, and it just gets repetitive. (School A, Interview 2)

The student in this interview then mentioned the possibility of learning to use Java Script or learning how to edit videos. It seemed that the point to take from this interview is that different students might connect with different programming languages and that spending too much time on a single language runs the risk of students never finding their way into the subject. These interviews make it clear that limited engagement with programming is also frustrating for the students.

Programming as Part of the Computing Curriculum.

Programming has become central to the computing curriculum, but is it necessary for young people to learn to write computer programs in order to be equipped for the digital world? What is the best way for student to learn to code? Does learning to code have any additional benefits such as teaching young people about computational thinking?

From the data collected from the young people, it seems that, at least at the time this data was collected, the right balance had yet to be found. The young people found it hard to see the point of learning to code (even if they found it interesting) and those who were most engaged in programming found that the lessons did not go deep enough. Conversely, the students who were not interested in programming could not understand why they were learning to write programs instead of learning other skills that they would be interested in.

There is clearly an argument to be made that young people will not always see the value of what they are learning when they are 14, even more so in a case like this where there is a new curriculum and it will be many years before the consequences of this curriculum are realised. However, this is a question that will be returned to in the next chapter when discussing the validity interviews with teachers. A question to keep in mind for the teacher interviews, is do the teachers see the value in focusing on Computer Science and programming rather than having a focus on how to use computers and software (ICT)?

5.4.4 Computer Science and Computational Thinking… Is This Important?

From the data presented here, it is clear that, while the intention may be for Computer Science, computational thinking and programming to be central to the computing curriculum, many of the pupils are finding these topics hard to engage with. Core to this problem is that the young do not seem to have strong idea of what computational thinking actually is, and the motivation and relevance for learning Computer Science is not being made clear.

There are some students who are interested in these topics and enjoy learning about Computer Science. However, a number of the young people interviewed struggled to connect the dots as to why they were learning what they were learning. They become less engaged and less likely to pursue computing when they see it as a subject dominated by learning to program in a single programming language; they have not made the connection to seeing Computer Science as an opportunity for solving problems in creative ways. Linked to this, the pupils do not seem to be developing an understanding of what computational thinking is. While they are able to make educated guesses about what this concept might be, as a new concept that was seen as a central to the computing curriculum, the lack of consistency in what pupils perceive computational thinking to be seems problematic.

5.5 Conclusion to the Data Presentation Chapter

This chapter has looked at the data collected through the group interviews with young people. In order to work towards answering the research questions, it has considered the young people's views of the digital economy, what they are learning in terms of digital literacy, and how they relate to computational thinking, computer science, and computer programming. Each of these areas has been put into the context of the definitions derived from literature review of the thesis.

The data regarding the digital economy shows that the young people are not really thinking about the digital economy specifically. While some pupils have clear idea of the careers they want to pursue, many do not. As such, their expectation of what they want to be learning in computing is formed by wanting a wide range of general skills that can be applied to a number of careers, futures, and situations (such as life skills). Whether the skills and concepts they are learning could be applied to a range of contexts, the young people do not have enough knowledge to make this connection. They still seem to see the majority of jobs requiring competence using specific (office type) software and want to be receiving instruction on how to use these tools. It may be that one of the hidden challenges of the computing curriculum is helping the young people develop an understanding of the broader digital world and digital economy as well as the value of the computing curriculum.

Regarding digital literacy, this thesis has taken forward a three-fold definition that includes: technical skills of using digital tools, the critical skills of engaging with digital content, and the social-emotional skills of engaging with communities online. The young people are already leading rich digital lives, engaging with a wide range of digital media and content as well as engaging with broad communities (across the globe) online. As discussed in Section 3.3.2, literacy is about having the skills to engage in culture—not just the basic skills of reading and writing—but understanding what one reads and the impact of what one writes. The young people interviewed still had many questions about using digital technology and expressed that they did not feel they had the skills they needed to use and understand these technologies. From the interviews there seems to have been very little coverage (beyond basic e-safety) regarding either engaging with digital content or engaging with digital communities. Computing may not be the only place where they learn these skills, but it is worth noting the pupils do not seem to feel they are digitally literate.

In terms of computational thinking, the young people seem to have a degree of confusion about what computational thinking is; while they are learning a number of concept and skills that could be related to computational thinking they do not seem to be making the connection between what they are learning and the problem solving or thinking skills associated with computational thinking.

While the young people interviewed for this project provided valuable insights into the impacts of the English computing curriculum, as discussed previously in Chapter 4, their experience and perspectives may not be fully formed or informed. To supplement this data, and to offer an alternative understanding and perspective of the impact of the computing curriculum, the next chapter will present data from the interviews conducted with the teachers working at the schools where the group interviews were conducted.

Table 5 - Codes used for the theme of Digital Economy (see section 4.4.2):

Theme	Selective Code	Axial Codes	Open Codes
Digital Economy	People	The people of the digital economy	• Naming computer scientists. The people of the digital economy
		The dark side of the digital economy	
		How people of different ages engage in the digital economy	
	Describing the Digital world	The dark side of the digital economy	Utopia vs Dystopia
		How people of different ages engage in the digital economy	• Feeling of anxiety, overwhelmed and ... pressure to keep up
		The people of the digital economy	• Moving too fast
		My choices about the future	• What I want to do with my life • Positive experiences • Negative experiences
		Using computers, now and in the future (time and tasks)	How using computers has helped me.
	How Engage in the Digital World	What are computers for and where would you find them	
		My digital record footprint and past	
		Creators vs consumers	

Table 6 - Codes used for the theme of Digital Literacy (see section 4.4.2):

Theme	Selective Code	Axial Code	Open code
Digital Literacy	Social Media	General comments about social media	• Social media platforms do you use
		Changes who I/other are or behave/personality	• Other people online • Me online
		Doesn’t change how I/others behave/personality	
	Online Communities	Online communities - people I don't know or see every day	• Friends in far places • Part of something bigger
		Online communities - people I know, go to school with, or	
		e-safety dump	
	Work vs. Leisure	Employment related comments	• Need ICT for work • Need CS/computing for work • I am learning the skills I need
		Leisure related (future)	• Using computers in the future
		What I use computer for now (and how it relates)	• What are computers for • How much time do you spend using computers?
	Knowledge and Skills Specific	Need to know and are learning	• Things we need to know and are learning
		Need to know and not learning	• Need to know but are not learning
		Don't need to know but learning	• Why are we learning this? • Things are we are learning ... but really don’t need to
		Don't need to know but no learning	
		Broader comments about who and why people are learning	• Fixing stuff

		Knowledge and skill and when	
		Does it matter how much you know	
		What I will remember... what is sinking in	

Table 7 - Codes used for the theme of Computational Thinking (see section 4.4.2):

Theme	Selective Code	Axial Code	Open code
Computational Thinking (CT)	Computer Science	Who is good at computer science/computing	• thinking like a computer scientist • key outliers
		Is it important to know underlying concepts (practical application)?	• Things about Computer Science that we just aren't learning
		What is CS and what is it good for any way	
		What is a computer	
		Hardware	
	Computational Thinking	What is computational thinking	• Computational thinking?
		Logic and problem solving in computing	
		What is it NOT	• Problems with CT
	thinking like a computer scientist	Changing how I think or behave	• what makes you good at CT.
		How do you get better getting things wrong, or right (at computing)	
		Question of age	
		Does it change how you use or will use tech	
	What about Programming	Learning programming (positive)	• Personal coding • The best thing about coding Is it useful?
		Learning programming (Negative)	• Is this all there is?
		Other coding related comments	• Careers in coding • Copying down from the white board kind of coding

Chapter 6: Teacher Interviews - Extending and Adding Context to the data.

6.1 Teacher Chapter - Introduction

Alongside the interviews with young people, nine teachers were also interviewed. These interviews have been used to extend and provide additional context to the young people's data and present another perspective regarding the delivery of computing in Key Stage Three. This chapter will present the teachers' views on the topics that arose from the young people, and also look at few topics that impact young people's experiences even it is not overtly clear to the young people themselves.

In many ways the teachers' perspectives reflect the experiences of the young people, so what these interviews do is bring a broader perceptive to the data previously presented. The teachers reported many of the same frustrations and concerns as the young people. They feel that ICT and computing are truly different subjects and that some things have been lost through the transition from one to the other. However, the teachers also seem less aware of the degree to which digital devices and media are central to the young people's lives.

From the teachers, there is little discussion of the social-emotional and critical thinking aspects of the digital literacy in particular. While the teachers are familiar with terms such as 'digital economy' or even 'computational thinking', they have been left to understand, interpret, and deliver these topics on their own.

This chapter attempts to use the teachers' own words as much as possible. As the teacher interviews were a mixture of semi-structured and unstructured interviews, it is not always possible to directly present the question they are responding to as the interviews progressed more as a discussion or conversation than a strict back and forth.

As the primary focus of this thesis was on the views of the young people, the analysis of the teachers' data focused on adding context to the young people's data. To do this, the analysis of the teacher data was conducted only once the data from pupils had been fully coded, analysed, and written up. Once this had been completed, the key themes that had emerged from this process were then used to find the aspects of the teacher data which most added context to these themes. Again, working from transcripts, the transcripts were sorted by the main themes of the thesis, then those split documents where coded with regards to the key themes highlighted in the previous chapter.

This chapter follows the same structure as the previous chapter using the open codes to organise each section.

6.2 Teachers and the Digital Economy

This next section looks at the interview data from teachers in regard to the digital economy. Looking at their understanding of the digital economy, and the broader digital world, to what extent did the teachers feel like the curriculum was relevant to the young people? This section also examines the way the curriculum has impacted the choices of the young people. One of the interesting aspects of the teacher interviews is that, in terms of the digital economy, the teachers, like the young people, had a limited understanding of the changing economy. For some of the teachers, this resulted in an optimism for the new curriculum, while other teachers took more of a conservative tone, raising concerns about what has been lost with the new curriculum.

6.2.1 Understanding of the Digital Economy

While there are always limitations to any method used (see Chapter 8), one of the limitations of the interviews with young people is that they may not have a full understanding of what skills and knowledge they may need in the future. As Teacher 3B put it: "again students' knowledge as to what the world of work is like is massively limited by the nature of their age and experience or inexperience."

However, in terms of the broader digital economy, one of the challenges is that the above criticism could also be made of the teachers. When discussing the ‘digital economy’ with teachers, each teacher framed the discussion in their own way, and while none of these framings were incorrect, these framings lacked consistency. This meant that for the various teachers, the concept of the ‘digital economy’ played different roles in terms of teaching computing.

For Teacher 2C, they felt that framing computing in terms of general technological development was critical for the young people’s understanding as they felt that the world was in the midst of a dramatic and fascinating transition:

Teacher 2C: I'll be dead and buried dudes, but you're gonna still be here, and you're right on the cusp of something, which is as exciting now as it would've felt in 1840 or something like that. It's that much of a magical time. We're the people that they will be laughing at soon for calling them driverless cars, which is a bit like calling them horseless carriages. But we laugh at them, and people will, right at that moment now.

On the other hand, Teacher 2A felt that things like app development and games development, while of interest to the young people, ended up being merely shoehorned into the lessons:

Teacher 2A: No. I mean, they've tried to shoehorn things like app development in, which is fine. And students have a keen interest because mobile phones. They're all using apps. And, the game-making. You find a lot of students do games. But you think of how many people that come out of school, that school environment or college, and how many people actually, realistically will be able to get into games development or games testing. It's very slim. So, they're trying to make it look more appealing, look more exciting.

But the be-all and end-all of it is, you've got some concept you need to learn, and you need to apply them to this situation. And that's it. Be given a task, a computer science-related task, and be able to break that task down, solve all the bits yourself. And come up with some kind of solution.

Teacher 1A, took a slightly different perspective. They felt that one of the interesting things about computing is that there is a distinction between the people who "just program" and those who have the "eureka moments". But that the digital economy needs a mixture. That said, they believed that the students needed to learn a wide range of skills to fulfil the needs of business rather than just teaching the kids to either be programmers or be computer scientists.

Teacher 1A: Say for example, that business comes up with that new bit of technology and it's been generated by somebody that does computer science. Who's going to do all the budgeting, who's going to be able to produce the reports? Who's going to have the skill set to generate that sales pitch? Yeah, I can come up with the words, but I can't express them because I ain't got the skills to communicate them.

The teachers seem to have had a lack of clarity about how relevant what the young people were learning was to the future and the digital economy. This leaves much of the content of the computing curriculum without context and, in some instances, without purpose. All of these teachers are addressing the feeling that the economy and broader world is in a process of change while the curriculum states that it should prepare the young people for the digital economy and future digital world.

6.2.2 Choice About the Future and Skills Getting Ready for the Workplace

From the teachers' perspectives, the question of how the computing curriculum was affecting young people's choices and preparing them for specific jobs was slightly complex. While the teachers could see that the curriculum was better preparing the young people for some roles (such as programming), there was also a feeling that they were also having other options taken away. Teacher 4C identified Computer Science as increasingly a "sort of underpinning discipline":

Teacher 4C: It is increasingly that sort of underpinning discipline that's-…Your ability, essentially your ability to be a lifelong independent learner. That's essentially what it ... yeah, that's what all this is predicated on, isn't it? Is that actually, in the future people are not going to be in a job for life. They're not going to be in a trade for life. And they're actually such is the technological change-

Interviewer: That's already happening.

Teacher 4C: Ultimately what you're trying to do is develop people with the capacity to retrain themselves on a regular basis.

The shift to a more Computer Science focused curriculum benefited some young people but also cut off others from essential content, leaving young people who felt less able to engage in the new content unable to access potential future careers and that, in the end, could be more practical than theoretical. Teacher 1C pointed out that in terms of jobs there was a great deal of regional variation. Cities may not need as many young people with programming ability whereas in rural areas there may be a lack of skilled IT people. And Teacher 2A acknowledged that, while it may be possible for young people to learn some skills on the job, other skills would be needed to even ‘get your foot through the door’. As such, young people might be expected to have ICT knowledge and skills they had not had a chance to learn.

Interviewer: The way it's being taught is forcing people to make that choice?

Teacher 2A: Yeah. I think you close a lot of doors with Computer Science on where they can go in the future. Just because of the limit ... The skill set that they will have isn't relevant for certain areas. Like, say that you can pick up and you can learn on the job. You can get apprenticeships. But it's getting your foot through the door at apprenticeships first. To be able to go on to the apprenticeships. To be able to go on to succeed in the apprenticeship. It's more training's gonna be needed in the beginning that shouldn't be needed because they should have learned the skills earlier on in their life.

They think they've gone forwards and they've gone ... Everything's now is focused on ICT. So, we now need to drop some ICT. And, the industry is saying that there's no computer programmers coming out of school. So instead of going for the balance, we've just done the same thing. We've dropped IT and then computer sciences. In a few years, it will go full circle and the industry will say, "Well, we've got too many computer programmers." No one's getting jobs because there's too many of them out there.

The computing curriculum had failed to consider a whole range of new careers which the young people could consider, but were not learning the skills for - such as Blogging, Video Blogging, using social networks for work - but the young people were not learning any of the skills needed for these environments other than basic safety.

However, on the other hand, having more of a focus on Computer Science has helped some young people make their choices about future careers; having a better understanding of what Computer Science could involve may have increased the likelihood of the young people choosing those paths.

Teacher 3C pointed out that ICT and computing are not equivalent, so the drop in uptake of ICT after year nine [3] may not be because young people are choosing Computer Science. Instead it may be because they no longer have a sense of what is involved in ICT.

Teacher 2B (who had background in Computer Science prior to teaching) saw this uptake in Computer Science as positive. They felt that the young people who were taking up Computer Science were more inspired to create things with computers:

Interviewer: Do you think that learning computing has affected people's decisions and choices about their future?

Teacher 2B: I think it has. I think much more now going to the programming side, the kids have gone to a lot more thinking of, "I can do something with the computers to see where I want to go." It's not, "I want to do this, I want to do that." It's, "I want to develop this, I want to develop that." If more kids are wanting to go down or are going off to do Computer Science for a degree, which has been quite positive ...

[3] At the time of the interviews the GCSE in IT was still an options open to students; this ceased to be the case in 2017

They also felt that there had been an increase in the take up of computing by young people with a real passion for the subject, and not just because they spend a lot of time using computers.

Teacher 2B: I think what we're getting now are kids that actually have the passion for it. Not they're good on the computer so they should take it. I think that's what used to happen. You're on the computer a lot, you should do it. You should do computing. We've gone away from that now. We've got very much into a, "I want to actually learn about it". I really want to see that passion. Again, they've got passionate teachers, they know that trust there as well. They know exactly what, who and where it goes through.

This quote highlights a real benefit of the computing curriculum as young people are really getting a chance to find out what computing was all about and develop a passion for the subject. One of the challenges is that computing is still finding its place among other subjects. Computer Science has become more of an academic subject as compared to IT/ICT; this has meant that some of the young people who could find success in the subject are having to choose between other highly academic subjects. While they may benefit from learning computer science, they have to choose to pursue other subjects that may be, or they may see, as more relevant.

Teacher 1C: I think a lot of kids either have no idea what they're doing or they're quite fixed. And many times, I kind of feel a bit - I have quite a lot of students who I would love to see to do A level [in Computer Science] because I think they would do really well. But it doesn't suit with their options, so they drop it. So, I have one of my best girls in year 11. She

> wants to be a GP; she wants to be a doctor. She's not going to do Computer Science. She needs her sciences for that.
> If students are going to get into engineering, then you need do physics, you need do chemistry because you might want to go into chemical engineering. And you need to do maths and further maths.

This echoes comments made by young people (Section 5.2.3), where some young people expressed having a clear idea of what they want to do in the future and having to choose subjects after Key Stage 3 to that reflect those choices which often do not fit being able to stick with Computer Science. Others have less of an idea of what they will be doing, but have an impression of Computer Science based on their computing lessons. Both the comments from the young people and the comments of the teachers seem to indicate that the computing curriculum as investigated through this study is not making the case for the need for computing skills in any career, or as an underpinning discipline. From the interviews with teachers and young people it seems that while computing was a welcome addition to the curriculum it was a mistake to remove so many of the aspects of ICT and IT.

6.2.3 Teachers and the Digital Economy

One of the difficulties of the computing curriculum is that teachers are struggling to contextualise it as much as the young people are. The teachers are also trying to interpret what the digital world facing these young people may look like. The curriculum, as written, may not be particularly conducive to being relevant to the digital lives of many of the young people. There is very much a theme throughout the interviews that while a more Computer Science focused curriculum may suit a small number of the young people, there were many who seem to have been better served by the content included in ICT.

The computing curriculum is giving young people a better sense of what may be included in further study of Computer Science. For those who are interested, this may be encouraging them to take up the subject, but this has been to the detriment of ICT. It seems that for the teachers, the two area are separate but equally important, but in practice ICT has been primarily replaced by computing.

In the context of the research questions, these comments from teachers raise issues and questions around the idea of the ‘preparing young people for the digital economy and digital world’. While the young people may be being prepared for the further study of Computer Science, it is less clear if they are being prepared for a broader ‘digital economy’ or even a ‘digital world’ where computers are a part of a wide range of careers.

In terms of sub-question one regarding specific knowledge of the digital economy, the knowledge of the teachers on the digital economy appears piecemeal, and inconsistent. Teachers are not sure what the young people need to learn to be prepared for the future. At the time of the research, the teachers did not seem entirely convinced that the computing curriculum was better suited for the young people than the ICT curriculum was.

6.3 Teachers and Digital literacy

The second research sub-question looks at whether students feel they are learning to be digitally literate. This section will look at the teachers’ understanding of digital literacy and the challenges they are facing in teaching it. Several of the teachers expressed that they feel digital literacy is of key importance but are struggling to find the time to teach it. As Teacher 1B expresses below, digital literacy is critical for young people, yet it has been all but eliminated from the curriculum:

Interviewer: What do you think the main purpose of the switch from ICT to computing has been?

Teacher 1B: The main purpose is, it's kind of ... It's to do with government's understanding and definitions. I think they see it as a more academic subject and I think I personally think it's a mistake, it needed both and I argued that quite strongly at the time. I do feel that there will be a switch back and really it needed both... It's such a big important thing in the curriculum. The thought that in order to get any job in society you need English, you need maths, and you need to be digitally literate and the thought that there's only one lesson a week for digital literacy and seven lessons a week for maths on a school curriculum, there is something wrong there. There should be more time to get kids digitally literate.

The following section will look at the teachers' views on the different aspects of digital literacy (technical/ICT skills, critical thinking skills, and social/emotional literacy). Finally, this section will return to the idea of class time. The quote above alludes to the fact that in all of the schools included in this study, the young people had only one lesson a week of computing, for teaching all of the aspects of the computing curriculum (including digital literacy).

6.3.1 Teachers and ICT

Similar to the young people, the teachers interviewed felt there was a significant failure of the computing curriculum to include ICT. All of the teachers interviewed expressed the value of ICT skills. For example:

Teacher 1C: Well it's the third computing subject. ... in computing you have your three strands, you have computer science, your digital literacy and then you have your IT skills. And I think the digital literacy is vital for a lot of students. And they are the skills we assume they have that they don't really have.

One of the teachers addressed what they found to be a significant misconception that young people had found IT (ICT) boring:

Teacher 2C: Well that's what I meant about the university stuff. On the one hand, you've got the universities and CAS setting up and guiding a process which. And go say then that kids find IT boring, ICT boring. In my experience, of over a decade as a teacher, no, they didn't.

For some of the teachers there was a real concern that, while the computing curriculum covered many theoretical aspects of Computer Science, there were basic or essential skills that were just not included:

interviewer: Do you think [the computing curriculum] is moving away from skill building?

Teacher 1C: I would say so. For me, there's an analogy where I don't know if I've expressed this to you before. That would be teaching children how to drive whereas the Computer Science is teaching them how to fix the car.

With one of the teachers going so far to say that one thing they would change about the curriculum would be the inclusion of more “life skills” in the curriculum:

Interviewer: If you could change some aspect of the computing curriculum, what would it be?

Teacher 2B: To change it? More an emphasis on life skills as well as the Computer Science side.

Interviewer: Do you make that distinct from ICT?

Teacher 2B: Yeah. Life skills, using the computers efficiently, competently and being confident to use a computer.

For some children that could be turning the computer on to do some office space work or office space scenarios. For somebody else it could be using the computer to manage stock control.

Among the teachers there was a repeated theme, regarding students *not going* into computing careers and whether they would have the skills they would need. This supported the idea that the curriculum had been driven by a need for more computer programmers and this had happened to the detriment of a wide range of skills.

Interviewer: What do you think is the main purpose of the change from ICT to computing?

Teacher 2A: I think that the idea behind it is that we need more computer programmers for the new age of technology. That's what I think it is. We think that technology's gonna move so fast that we need to keep people coming into the industry to keep things going. To keep things developing. And, to look to the future. But, at the same time, we're forgetting about one of the most important things.

Office workers and people like that are gonna need basic office skills. Or, the Web developers that have no experience in Web development until they get into college. And then, they're behind where they should be because they should have had experience in Web development at key stage four. Or, your animators. Because animation is more an ICT-based topic.

There was also a concern that there was a whole set of what could be called ‘advanced’ ICT skills which had completely disappeared. These included skills that many adults may not have had such as advanced spreadsheet skills and word processing skills such as mail merge. These advanced skills were unlikely to be taught in other lessons but had been crowed out of the computing lessons (Teacher 3C) and that the basic skills really were not suitable for industry:

Teacher 3C: Yeah. You can bumble on with very basic skills, or you can be given more sophisticated skills than the vast majority of adults have.

I felt that over, maybe I don't know, the first 10 years or so of teaching here, that is what we were doing. We were teaching pupils skills that their parents didn't have. That was advance spreadsheet things and database things and word processing things, and PowerPoints. It’s extraordinary, PowerPoint can just be used, can't it, as being a ridiculously trivial way of presenting something about dinosaurs, or it can be used in your working life to convey information to people at all sorts of levels. We are reduced now, we've gone back to, kids have the skills of doing a ridiculous dinosaur presentation, instead of being able to use it in real industry.

One of the interviews for this project was with a school administrator, who had managerial oversight for computing in that school. They highlighted that the teachers in other subject areas had previously taken for granted the ICT skills of the pupils and were now surprised when the pupils did not have the skills needed for these other lessons (Teacher 3B).

While it is clear that the teachers also saw a problem with the curriculum in terms of the teaching of ICT skills, it seems that their experiences were based on what had been taught before. In contrast, the young people's impression of the missing aspects of ICT were based on what they thought they would need to be successful in future life. Skills such as cybersecurity were not mentioned by the teachers but were featured by the young people as a key skill.

6.3.2 Critical Thinking Skills, Content Creation, and Other Jobs

The literature reviewed in this thesis highlighted that critical thinking skills are an important aspect of digital literacy. From the interviews with the young people, it seemed that they did not feel that computing was a very creative subject that could include aspect of either content creation or critical thinking.

Critical thinking was similarly absent from most of the teachers' interviews. Teacher 2A, said there was a recognition that the jobs of the digital economy were far broader than "just programming" and that the young people already aspiring for that would include 'media creation', but were not learning the skills needed for these futures. Teacher 2A (whose background was in ICT, specifically), was concerned that the narrowing of computing as a subject would only continue as teachers with an ICT backgrounds were replaced by teachers with a more explicit computing and Computer Science background. Those replacement teachers would likely not include, or see the value of including, broader ICT skills in computing.

Teacher 1B was concerned that there was an impression that these young people were 'digital natives' and they did not need to learn to certain skills. This teacher highlighted that, in their school, teaching digital literacy skills inevitably ended up taking more time although they had allotted 8 weeks (with one lesson a week) for delivering the content.

6.3.3 Complex Digital Lives

The teachers interviewed had a sense that the curriculum did not really reflect the digital lives of young people. They also seemed to have a limited understanding of what these digital social lives might involve.

Interviewer: To what extent do you think the computing curriculum relates to how the kids use computers in their everyday lives, if at all?

Teacher 2A: Students use computers really to game, to communicate, social network.

Interviewer: Do you feel like the computing curriculum, the curriculum as you're delivering it is removed from all of those things? From gaming, from social networking-

Teacher 2A: Yeah, the social network is falling on [safety], which is good, which is still highly relevant. The gaming I suppose to a certain extent but it's too focused. It's on your interpretation of what needs to be taught and how you're going to teach it. You could teach concepts of using loops and using selection statements by making your own games, but I think it's harder to deliver those things making games than it would be just to do some solid coding. You spend more hours delivering it. Gaming to a certain extent. Communication not so much.

There was a hope from the teachers that the key lessons regarding staying safe online would sink in. The teacher (below) hoped that the young people would understand how and why to deal with common digital issues (such as phishing issues).

Teacher 2B: I would hope with where we are now that they'd be able to understand why we're doing the curriculum we did five, six years ago. I think if they've done some programming, they might have come back to program, especially if they're doing science subjects. Even if you're doing math, you probably still have to write a program to do things. It's between that transferrable skill that is quite useful for the subjects. The actual insight into computer, that's more of an awareness and the passion, I guess. The literacy side, the safety side, hopefully they'd be able to understand how and why they're kept safe or, "I got that spam email and I remember that lesson we did and I knew it was a spam and I knew how to ... it was a phishing email", what not, "And I knew how to get rid of it."

There seems to be little recognition in the teacher interviews that young people may need to be taught the social skills for navigating their digital lives. While on a superficial level this may not relate to 'computing', based on the literature reviewed in this thesis, with a broader understanding of digital literacy, the social-emotional skills are key ingredient.

What seems most significant is that, while the literature and the young people's reporting of their own lives highlight the importance of social-emotional skills, these skills do not feature highly in the curriculum itself or in the teachers' insight about the curriculum.

6.3.4 Limited Time for Computing.

In a number of the interviews with teachers (Teachers 2A, B1, B2, B3, C1, C2), the issue with of having limited time on the timetable to teach everything in the curriculum came up. While this does not directly relate to any specific issue raised by the young people, the young people did express the desire to learn "computing and ICT".

For teachers there were three specific aspects of not having enough time. The teachers felt that the amount of time devoted to computing was not enough for the 'penny to drop' (Teacher 1A) in terms of learning to program.

Interviewer: What do you think is the hardest thing to teach though in the computing curriculum.

teacher 1A: Aptitude. You know, we can teach it, can't we? It's the same as, I think for some penny drops, others, penny takes too long to drop. In the time that we have. It may drop eventually but I don't necessarily believe [that it will].

Teacher 3B highlighted that while many of the ICT skills were expected to be taught across the curriculum, that other teachers did not have the time to do this. Additionally, the computing lesson could also not fit these skills into the timetable:

Teacher 3B: I'm aware as head of department, a few years ago I used to be head of science, and a teacher would come to us and sort of say, "ICT time is limited. I need you please to make sure that you are teaching these aspects of ICT within science." Depending on the aspects you're asked to deliver, that was sometimes very straightforward, and other times it was a real challenge.

Teacher 2B also discussed how important it was for the young people to be able "to know how to use [a computer] competently", but that did not fit within the school timetable as there was so much emphasis on the Computer Science aspects.

Teacher 2B: Every job that you go into these days has some sort of computer. As well as knowing how computers work, which is the Computer Science side, you also need to be able to know how to use one competently as well.

interviewer: You think they're losing that?

Teacher 2B: We're still doing it to an extent but it's a much more streamline process than what we used to do.

Interviewer: Do you think that should be fitting in somewhere?

Teacher 2B: Somewhere it should be, but the problem schools have is timetable and time.

This teacher also highlighted that because there are no specific qualifications that included things like interacting with 'digital public services' these skills were not included in the curriculum regardless of how important they may be.

Finally, Teacher 1B felt that there seemed to be a perception that, by default, young people would know how to use software, but this just was not the case in their experience.

Teacher 1B: I find it bizarre that the government is taking [ICT] off timetable because there is this naïve belief that because a child has an iPad and can swipe across a screen that they can use software effectively, and they can't.

While it seems that there is a role for digital literacy in the computing curriculum there is a real question of how anything else could be fitted into the existing timetable without computing being given more hours in the week.

6.3.5 Teachers and the Context of Digital Literacy

The research questions of this thesis ask whether young people feel they are learning to be digitally literate through the 2014 computing curriculum. Based on the interviews with the teachers, it seems that the teachers feel that digital literacy is critical but are struggling to figure out how it fits within the structure of the curriculum. While the lack of time is a struggle across the curriculum, this seems to be most relevant with digital literacy, where the teachers feel they do not have the time to include something that they think is critical to the young people's futures.

6.4 What Teachers Think About Computational Thinking

The 2014 English computing curriculum puts computational thinking, Computer Science and programming at the heart of what young people should be learning in their computing lessons. These themes were used directly as analytical codes within the analysis of both the pupil and teacher data. From the young people's perspectives, all three of these things were problematic in different ways. The following section looks at teacher experiences in these areas. In many ways, the teachers validate much of the young people's experiences, while at the same time giving more depth of understanding as to why these topics are important and where some of the difficulty comes from when it comes to teaching them.

6.4.1 Teachers and Computational Thinking

The interviews with the teachers confirmed that even among the educators (in 2016-2017) there was little consensus as to exactly what computational thinking was or what it was good for. Not only was this the case but some of the teachers raised the concern that computational thinking was not accessible to all of the young people equally.

For Teacher 1C, computational thinking was the underlying concept for all of computing, in that it was the ability to understand the functioning of the computer. However, this teacher also believed that computational thinking was as difficult to understand and apply as something like physics.

Interviewer: What do you see as the role of computational thinking within the computing curriculum?

Teacher 1C: Well it’s kind of underlines everything isn't it? Everything that we do is that, but we don't say it is. So today, my students were programming and in order to solve something they really have to think about why we're doing certain things. But even when we were doing graphics, that's computational thinking. How does the computer save it? How does it do it. So, it's kind of part of all of it, isn't it? In a sense we were teaching big algorithms. That's all computational. Its problem solving. It's all of it.

Interviewer: What do you think are the limitations of computational thinking?

Teacher 1C: I think it's limiting to less able students.

Interviewer: What do you mean?

Teacher 1C: I think a lot of the less able students - so now I'm taking about GCSE's I don't think the curriculum is accessible to less abled students. I think it's too hard for them. I guess you can say that's true for a lot of subjects, but it is up there with physics and it is tricky.

While the above quote above refers to computing at GCSE level, it seems worth considering the implication: that Computer Science GCSE, which the students see as critical to a wide range of careers and futures (see Section 5.2.3), is only accessible to the most able students.

For Teacher 1A, their experience was that some young people could not understand why they were learning all this “thinking stuff”, while Teacher 2C felt that the case had not been adequately made for why young people need to learn computational thinking. This teacher was specifically concerned that the language used to describe computational thinking was alienating to young people.

Teacher 2C: I'm still not sure that CAS has ever really countered the ... Aren't we trying to produce a generation of coders, or what? Is it really just about coding? I don't think that this ... Even though people talk about Wing, and the bloody definition of computational thinking and all that kind of stuff, I don't think we've got anything really, which is properly ... Without using bullshit words like abstraction, and pattern recognition, and generalisation. Give me something which will immediately, within eight words, sell it to a 13-year-old.

…

Teacher 2C: It doesn't mean anything to these kids. You try using big words like decomposition to a 13-year-old. You say right, so you want me to break different ideas down into small things. Yeah, well I do that all the time, and I've been intuitively doing that since I was four. Is that all you've got in your locker, really?

Interviewer: Or even longer.

Teacher 2C: So, what are we saying? We look for patterns, we hide things away, we break things down. Really? That's what we do all the time anyway, you know. It’s kind of is, isn't it? I don't think we've got a basic rationale for selling it to 13-year-olds.

While the above could be said of other subjects, what Teacher 2C was saying is that the language of computational thinking is not useful for trying to convince teenagers of the value of computational thinking. This is further complicated by the newness of the computing curriculum. While the justification of learning other subjects is more established, teenagers need to be ‘sold’ on the value of computing. If it is something, they ‘do all the time’ already, then (as the teacher seems to indicate) the pupils think ‘is that all there is’.

Teacher 2A, most directly raised the conception of computational thinking as a problem-solving tool, using the language developed by CAS to describe the computational thinking problem solving process.

Interviewer: How do you interpret the concept of computational thinking? And what do you see as the role of computational thinking, within the computing field?

Teacher 2A: As we do in every part of our curriculum, it's more taking problems and developing solutions to problems and wording them in a way that computers and humans understand. So, you're looking at things like abstraction, decomposition, pattern recognition, algorithms. That's the way we're seeing it going, at the moment.

This teacher could see how computational thinking could help young people think more logically and solve problems using computers, but they raised the concern that computational thinking was only one approach to problem solving and students were not being introduced to other forms of problem solving.

Interviewer: So, you don't see computational thinking as necessarily a useful way of problem solving in lots of areas? It's a way of doing it for computers.

Teacher 2A: I do, yeah. I'd say more for computers. It does help you think logically and help you solve problems. But, I think, because of the nature of the problems that you would solve with a computer, I don't think you would benefit greatly from problems outside of there. You could still apply those skills to other problems outside. Practical problems. But, no, I don't think ... The relevance isn't there as much as I think people like to think that there is.

interviewer: Yeah. I think that's completely fair, actually. And I think, often, you get people from within the computing education world who are convinced that computational thinking is just the best thing.

Teacher 2A: Yeah. It is a good thing. And they will become really good problem solvers and things like that. But I think that the problems they will be able to solve aren't problems that you would face all the time, in day-to-day life.

When they come out of secondary school and into industry or when they go on to further education or on to the workplace, because they're not. The skills to think logically, and think through things, and break things down into small problems is a good skill. But being able to do it in reality isn't always the same as doing something that you could do on a computer.

While computational thinking is clearly a form of logical problem solving that can be particularly valuable when solving problems with computers, some of these teachers are raising the questions of whether the case is clear enough for young people in Key Stage 3 to be learning computational thinking. Teacher 2A raises the issue that, if computational thinking is fundamentally a problem-solving skill, it should be taught alongside other forms problem solving.

6.4.2 Teaching Computer Science at Key Stage 3

When considering the role of Computer Science within the curriculum, the fact that this fieldwork started only two years after the implementation of the 2014 computing curriculum, was very relevant. Teacher 1A, (who was head of department) felt that Computer Science would need to be more central to computing in the future, whereas programming was taking up a great deal of time at the moment. As young people prepared for the Computer Science GCSE, they would need to build a stronger understanding of the theory of Computer Science.

However, this teacher's colleague (Teacher 2A) was more concerned that more of the ICT skills had been pushed out of the curriculum by problem solving, programming, and Computer Science, and that this shift in emphasis was not suited to all kids:

Teacher 2A: This is a sore spot because I don't think [computational thinking] is relevant for everybody in the curriculum. I think that ICT still plays a major role in industry. I think we're focusing now, mainly, on Computer Science and programming and logical thinking. The logical thinking side behind it and the breaking problems down. Solve problems and solving those first is really useful as a general life skill. But I think it's still very much subject-orientated. Subject-specific. It's only if you're interested a career in that particular area.

The other concern this teacher raised was that, due to the focus on programming, many people (young people and adults) were becoming convinced that Computer Science and programming were synonymous. In fact, they felt that the focus on code and Computer Science could become a barrier to engaging the kids in the more fundamental aspects of computational thinking and problem solving—the skills they may be able to use to apply at a future date.

Teacher 2B, however, brought an interesting perspective to the conversation as they were one of the few teachers interviewed who had completed a degree in Computer Science prior to becoming a teacher. One of the things they highlighted was that, while it is possible to teach programming without teaching any other aspects of Computer Science, it is not possible to teach Computer Science without including programming. It was essential for teachers to have a solid understanding of Computer Science to be able to take the young people further.

Teacher 2B: The emphasis at the moment is more on the program side. There's some theory that we touch on, but it is much more the logic creating an algorithm, decomposing an algorithm, or actually it goes through. That is very much the focus at the moment.

Interviewer: As someone who has a background in Computer Science, what do you think?

Teacher 2B: You mean both don't you? It's like the chicken or the egg. In that syndrome, you need to have a good programming knowledge to see how you can experiment. As a science member, you have to write your programs so you can experiment what's actually happening with the hardware or why is the software doing it this way.

You also need the technical knowledge of how the software works or how the computer's displaying that in different ways. Just trying to make sure you can marry the two together at the right level for the kids.

Interviewer: Yeah. Also finding that mixture, I think programming, you can teach as an ICT almost, as a skill.

Teacher 2B: You can. Again, it's done as a competency of the teacher of what happens when a kid gets stuck. That's probably our hardest bit. I could teach any teacher how to program but if they don't actually do the programming themselves, or they don't go a little bit further ahead of themselves, if the child gets stuck or they go a little bit further ahead and then get stuck, it's that.

This teacher raised the concern that, without this fundamental understanding of Computer Science, teachers could end up conveying misconceptions to young people about how computers work—even if they were able to teach basic programming.

Teacher 2B: If it was in theory, I'd be looking at making sure they're using correct terminology. It's very easy in Computer Science to say one thing, use the wrong word and it means a completely different thing.

Interviewer: What example?

Teacher 2B: An example, let's look at processor. Common misconception is that it's the brain of the computer. That's partly true, though that's not entirely correct. The processor's job is to process all the instructions, perform and execute cycle; that would be the sort of difference I'd be looking for a teacher to pick up on. The kids go for basic, "It's the brains." It's kind of the brains, let's see if we can get a better definition for it.

From these interviews it seems that the role of Computer Science within the curriculum is unclear to the teachers, but it is also being hampered by a lack of fundamental understanding of the academic discipline. Where teachers had been able to learn how to teach programming in the run up to the implementation of the 2014 English computing curriculum, it seems that those teachers who did not already have a background in Computer Science did not have time to build up that understanding in so short a time. This lack of knowledge on the teacher part has been mixed with a lack of clarity on the purpose of teaching Computer Science for both the teachers and the young people. At least in the minds of some of these teachers (and pupils), the case has not been made clearly enough as to why Computer Science is a more fundamental and essential subject for all students to learn in comparison to ICT.

6.4.3 Teaching Programming

For many of the young people interviewed in this study (Section 5.4.3), it was hard to understand why they were learning to program. When speaking to a number of teachers for this thesis, programming came up as the thing that was most time consuming to teach. From the teacher interviews, the impression came across that teaching programming was beginning to dominate the computing lessons.

The teachers put forth a number of reasons as to why programming was taking up the majority of time. Teacher 2A highlighted that, while many of the young people had used the block-based programming (such as Scratch) in primary school, they had not really addressed the underlying concepts which meant that once they entered secondary school, the teachers had to spend more time on these concepts:

Interviewer: I’ve definitely come across that at primary school, where the teachers really struggle to feel like they know what to cover. Or how to cover what they need to cover. It feels very foreign to them. Often. Even something like Scratch, which is pretty easy to pick up. I think it feels very alien to what they're used to.

Teacher 2A: Mm-hmm (affirmative)- I mean, Scratch is used a lot. Yeah. At a lot of primary schools. We find that they come in, the students, and say, "I'm here. I've used Scratch before in primary school." But when you get down to it, they've not really done a great deal. And they don't understand what they've done. For them, it's just a building blocks exercise that does something nice. It's very colourful. There's a character, sprites on screen. It's the concepts behind it aren't covered.

Whereas Teacher 1A felt that many students just found it difficult to transition from block-based programming, where they (thought they) understood the concepts, to text-based programming. Again, the limited time came up as an issue for teaching programming. Teacher 2A, pointed out that the young people struggled to get enough practice in a single hour a week to become sufficiently fluent in a single programming language, let alone two languages (as required by the curriculum).

Teacher 2A: The hardest thing to teach. Judging from what we've done, over the past few years, the hardest thing is the programming language. It is like learning a new language. Your French, your German. Because I think the only way to really concrete those skills and be able to get and know all the syntax errors and the syntax you need to have is by using it regularly. And using it for one hour a week. And getting as much as you can in, for one hour a week.

If students go away and they don't have an interest and don't really want to go and do any more work on it, you are gonna fight a losing battle each week.

Teacher 2B, who had a Computer Science background, also felt that programming was taking up the most time. While programming was fundamental to computer science, programming only made up 20% of the student's final mark, but the students needed to competent programmers to handle the most advanced theory.

Interviewer: What part of the computing curriculum do you think eats up the most time?

Teacher 2B: Eats up the most time? Probably the programming side.

Interviewer: Do you think that's right, or do you think ...

Teacher 2B: In some ways it is. In some ways it's not. I was going back to when I was doing things at Uni and the way they taught it, it was more or less probe and probe and probe and then it went into theory.

You need the programs to be able to do the experiments in the science side of Computer Science. Unless you're happy at writing small programs, you're going to struggle with the advanced side of the theory.

It takes up the most time but it's one of these strange things, in a qualification it's the least amount of percentage and well. The program exercises that they do are worth 20% of the final mark. The theory is 80%. The problem solving is 40% of the 80%; they have to be able to do the program, for the expert to see how the problem solving is from it.

Programming has become a major barrier for many of the pupils to learning computing. While programming does not have to be central to the computing curriculum, the young people needed to be able to program in order to be successful in the rest of the curriculum.

The difficulty that is described by both young people and teachers is that programming had become isolated and taught more or less as a discrete skill. This was not the aim of the curriculum but comes out of a misconception about computing— that the major change from ICT to computing was the introduction of programming (as there was no programming included in the ICT curriculum)—rather than the inclusion of a deeper underlying theory of Computer Science. Teacher 4C, who had been very involved in Computing at School, puts it this way:

Teacher 4C: When we were trying to articulate what we meant by computing to most people, if you said, "what's the difference between IT and computing", they equated computing with programming. Now whereas right from the early days of CAS, and again if you look at all the back issues of 'Switched On', it was a theme I was trying to push right from the word go was that, actually, if you see ... The problem with the IT curriculum, was that you taught databases you taught spreadsheets, you

> taught Photoshop, you taught whatever. There was no unifying underlying principle to what you did in Photoshop that you could take into spreadsheets and so on.
>
> Now, if you take programming as just another isolated skill, that's equally the case. So, it's just another narrow skill. So actually, what we were really about, was saying "what are the unifying concepts that run through, whatever domain you want to explore."

From the young people's perspectives and the perspectives of some of the teachers involved in this study it seems that the difference between computing and ICT was in ICT the young people learned a range of useful but unrelated skills that they could clearly see the value of. Whereas with computing, they are now learning a range of related skills that the pupils, for the most part, could not see the value of. At least at the time the data was collected for this thesis, there was yet to be evidence of the 'unifying concepts' of computing being communicated to the teachers or pupils.

6.4.4 Final Thoughts About Teachers on Computational Thinking, Computer Science, and Programming

The skills of Computer Science, computational thinking, and an inclusion of programming would, it was argued, better prepare young people to be active participants in a future digital world (DfE, 2014). Looking specifically at these three aspects of computing from both the young people's and the teachers' interviews, there seems to be an imbalance in what has taken priority. Both teachers and young people feel that a great deal of time is being devoted to teaching programming both as an end in itself, but also so that the young people can access the more complex theoretical aspects of Computer Science. Computational thinking, while in some ways problematic, can be seen as a set of valuable skills that has strong place not just in computing, but also to become a powerful skill for young people to take forward.

For the teachers interviewed, it seems that they are facing a number of challenges. First, as a substantial academic discipline, to teach Computer Science to Key Stage 3 pupils requires a depth of knowledge (Teacher 2B) which, in the early years of the curriculum, many teachers may not have had. One teacher had been able to learn how to program in a short amount of time (Teacher 2A) but, as has been highlighted, programming is not Computer Science. Not only did the teachers not have sufficient knowledge of Computer Science to teach it, they seemed to struggle to make the case for why Computer Science, specifically, should be taught at this level. Computational thinking was seen as valuable but, between these interviews with teachers and the interviews with the young people, it is not being taught explicitly enough. The young people are still confused about what it is and why it would be useful. Computational thinking could be seen as the missed opportunity for the computing curriculum. Programming is taking up the most time to teach and seems to be the most difficult for the young people to learn.

In terms of the third research sub-question, as to whether young people are learning to apply the principle of computational thinking, these interviews provide evidence that there is still not enough clarity among teachers as to what those principles are, how they can be applied, or how to teach them to young people.

6.5 Conclusion to Teacher Interviews: Extending and Adding to Data

This chapter has used teacher interview data to add depth and context to the main findings of this thesis. Many of the main points raised by the young people were echoed by their teachers. The computing curriculum set out to be more rigorous and theory-driven than

ICT. Computing does seem to be a ‘harder’ subject than ICT, but it is still being given the same amount of time in the timetable as ICT had been, and this is presenting challenges for young people and teachers. With limited time to deliver computing, the young people can only be introduced to so much. Due to this time pressure, it is a challenge to make the subject relevant to a wide range of young people. This has also meant that skills that many of young people would like to learn are no longer included.

In terms of the digital economy, the teachers and young people have limited context for the purpose of much of what is being taught and, while the skills and knowledge could be highly relevant for the young people to navigate the future digital world, not all of the teachers have the background knowledge necessary to bring to bear on the teaching of computing (see Section 6.2.1). While computing may encourage young people to study Computer Science further, this will only ever be a subset of students and, as a more ‘academic’ subject, some of the most apt pupils will not be able to choose Computer Science due to having to take other ‘academic’ subjects. While computing may be opening up the choice of Computer Science for other students, it is limiting their choices in other areas.

Digital literacy is seen by students and teachers as a key skill and the thesis has looked at a broader understanding of digital literacy. However, this breadth of digital literacy does not fit well either within the computing lesson or the broader curriculum, so that while digital literacy may be essential for the young people to learn, how and when to learn this becomes a challenge. The young people cannot be seen to automatically have the basic skills aspects of digital literacy, and teachers are struggling to fit this in. This is not to mention the more advanced ICT skills that many young people may need but are not being taught. Teachers do not seem to have considered this broader conception of digital literacy. If the computing teachers tend to have more of a specific Computer Science background, they may not see the relevance of even including the basic aspects of ICT, instead choosing to focus more on the theoretical aspects of computing.

Fundamentally, the computing curriculum has been focused on including more Computer Science in the education of young people from an early age. While the young people are learning how to program, the purpose of this is still unclear (to pupils and teachers) but programming is taking up a great deal of time for the young people to learn (as this is seen as a core part of the current curriculum). Specifically, learning text-based programming seen to be time consuming. The aspects of Computer Science that are being taught (such as binary numbers) are confusing to young people, and for teachers without a Computer Science background it can be hard to take to these concepts to a further depth. The lack of clarity surrounding computational thinking, leaves teachers feeling that while it is a highly relevant and applicable skill, they are unsure about how to fit it in. Equally, there is a concern that computational thinking is only one form of problem solving and may not be useful in every circumstance, so there are the questions of teaching computational thinking in isolation without the context of other forms of problem solving that may be more appropriate in other circumstance.

Finally, it seems one of the challenges of the computing curriculum, is that while the case was made to policy makers as to why computing should be more Computer Science based, the case was not made more broadly, to teachers, parents, or, most specifically, to young people.

Chapter 7: Discussion and Recommendation

7.1 Discussion, Conclusions, and Recommendations

The purpose of this discussion is to pull together the main observations from the data and present answers to the research questions. Following the structure used throughout the thesis, this chapter will address the three themes —digital economy, digital literacy, and computational thinking—and will present a framework based on these three themes in light of the data from teachers and young people. The discussion will return to the overarching research question in the final sections.

The overarching research question developed and considered throughout this thesis has been:

Research Question:

To what extent do the young people subject to the English computing curriculum as delivered at Key Stage 3 and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

This research has been developed in the context of the introduction of the computing curriculum in 2014. Since this point, most young people in state schools in England should have experienced some form of compulsory computing education (Woollard, 2018, p. 22). The computing curriculum set out to ensure that young people are 'active participants of the digital world' (DfE, 2014), giving them the skills to help them make choices about how they would like to engage in the digital economy. The computing curriculum aims to "ensure that pupils become digitally literate" (DfE, 2014). The question of the impact of this computing education, has been the focus of this thesis.

This chapter will present a framework for each theme of the computing curriculum that will be presented at the end of each theme subsection, and will put the comments from the young people into the context of the literature, the National Curriculum, take into account the comments from teachers, and start to outline the conclusions for this chapter. Each framework presents the research question which relates to the theme, as well as the analytic codes which have been applied to draw insights from the data with regards to each theme. It then reflects how each theme is presented in the curriculum, how it has been defined in the literature and compares this to the primary insights from the young people, teachers and the experts interviewed for this thesis. Each of the frameworks also presents a concise conclusion for each theme. The frameworks are presented as a tool to be applied to either future research or future curriculum development. These frameworks were developed as a core consolidation of the research in this thesis to highlight the main findings and most importantly the logical narrative that has informed those findings.

This chapter will conclude with the views from the three expert interviews conducted as validation for this thesis (Section 4.5.2). The three independent experts were provided with a summary of this chapter and the associated frameworks, before being interviewed about how the findings of this thesis were reflected in their own experiences.

7.2 Digital economy

Central to this thesis is the connection between the computing curriculum and the digital economy.

While the computing curriculum sets out to prepare young people who will directly enter the digital economy as programmers, Web-developers, computer scientists, or network administrators, every young person in a state school in England is subjected to the computing curriculum, so the questions must be focused on how well are all young people served. Does the computing curriculum develop young people understanding of the digital economy so they can make better decisions about the future? Previous research has found that pupils' perceptions of their future uses of computing and ICT skills are dominated by their school and the course they are following (Bradshaw, 2018, p. 46).

7.2.1 What is the Digital Economy We Are Aiming For?

This thesis has explored the digital economy as a timeline that describes very different periods which have been defined by strikingly different technologies (Section 3.2.2).

The young people have little sense of how they will use technology in their future careers (Sections 5.2.2 and 5.2.3), and a limited understanding of the people who have shaped the digital economy (Section 5.2.1). This limits the number of young people who can 'see themselves' as part of the digital economy in the future. Livingston and Hope (2011) presented the "NextGen" report to make the case that while the UK was leading in the fields of Games Design and Special Effects (specifically) and the digital economy (in general), without a change in the curriculum the UK would not be able to maintain and economic lead in these areas. While the curriculum did change subsequently, from the interviews conducted, it is unclear if the young people are receiving the skills they need to enter these industries.

From this thesis, there is little evidence that young people are gaining anything more than the basic technical (e.g. programming) skills to enter these fields (Sections 5.2.3 and 5.4.3). The young people involved in this study did not see computing as a particularly creative discipline. While some young people did express the desire to work in the games industries, it seemed that this came from the young people's interest in computer games (as players) rather than any influence of the computing curriculum (Section 5.2.3). Equally importantly, several young people discussed their negative experiences with computing and how that had made them less likely to take on careers that may require a large amount of computer use and knowledge (Section 5.2.3). While some of the teachers interviewed had wider knowledge of the broader digital world, this was primarily from personal experience or interest. Generally, they had not thought about how the skills they were teaching were preparing young people for a broad digital economy. They saw the digital economy at a critical point of change (Section 6.2.1).

Many of the skills associated with the industries which 'Next Gen' focused on such as animations and media editing have been replaced by a focus on Computer Science, computational thinking, and computer programming.

7.2.2 Understanding the Digital World Around Them

New technology is deeply connected to society, and Lyon (1991) questions whether the social effects of Information Technologies in our 'new kind of society' are generally benign (p. 94). Additionally, if as Carlson (2004, p. 262) proposes, the Internet and networked computer systems are "General Purpose Technologies" on par with electricity or the steam engine, then society is potentially going through a significant transformation. The assumption, however, is that young people will take technological developments in their stride. From the data, the young people involved in this study do not feel they understand or can easily keep up with the technological developments they have seen even in their own lifetimes.

The young people are aware of the arguments about the changes in society, but do not feel like they have influence over these changes. To paraphrase Lyon, these young people could be said to have accepted that technological progress and potential are determining the ’social destiny’ (Lyon, 1991, p. 94).

Can computing education help give the young people more confidence in using technology and reassurance about future technological developments, helping young people make sense of a digital world which they are living in? Two of the aims of the 2014 computing curriculum are to ensure that all pupils:

- *can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems*
- *are responsible, competent, confident and creative users of information and communication technology.* (DfE,2014, online)

If these aims are to be achieved, it seems there might be some discussion as to how we should understand new and unfamiliar technologies and this should go beyond just technological implications to also address social and economic implications. However, neither the young people nor the teachers reported that these sorts of discussions took place at the Key Stage 3 level.

If young people (as reported in this thesis) feel concerned, overwhelmed, and uninformed about new technology they will not be able to apply those technology or use them as “r*esponsible, competent, confident, and creative users”.*

Computing education, if it is to engage and inform young people about the digital economy, must be engaged in emerging and new technologies, giving young people the tools they need to evaluate and make decisions about what technologies they use and how they use them.

For example, young people should have accurate understandings of the privacy concerns, with regards new technologies such as to smart home, smart speaker technologies, or driverless cars (and other data gathering and 'smart' technologies). While the current curriculum includes the subject content:

- *understand a range of ways to use technology safely, respectfully, responsibly and securely, including protecting their online identity and privacy; recognise inappropriate content, contact and conduct and know how to report concerns.*

It is important that this statement leaves room for young people to investigate and understand the affordances (Woollard, 2018, p. 19) of different technologies, e.g. are some technologies inherently unsafe? As a user of technologies, do you need to think about how those technology could be abused or misused?

This is a tall order because it demands that the content of computing education be dynamic and driven by new technological developments, which teachers themselves may not know the implications of.

7.2.3 Understanding the Choices They Are Making

While computing is seen as most directly influencing young people's choices about whether or not to take a GCSE in Computer Science, young people's experiences in computing are affecting their decisions about any number of careers. From what tractors they want to buy in the future to whether they will aspire to be a pilot in the Royal Air Force, the young people involved in this study reported how computing had influenced their decisions about the future in many ways.

These choices are rooted in their understanding of both the broad digital economy (the impact of digitisation across all sectors) and the narrow digital economy (sectors specifically dependent on digital technology). As Brynjolfsson and McAfee (2014) highlighted, while jobs like gardeners and cooks may not be directly at threat of digital replacements, many jobs will start to be complemented by digital technology (2014, pp. 202 & 237). Thinking of the young woman in this study who spoke of wanting to become a nurse but hoped she would only need to use computers to "look up information and stuff" (School B, Interview 2), she may find herself working alongside an artificial intelligence system to help with diagnoses (Brynjolfsson and McAfee, 2014, p. 92). This young woman may find that, while nursing as a profession is not at risk of being replaced by automation, it requires a high level of technical skill and knowledge.

The young people do see computing as important even though they do not always see the connection between what they are learning and the skills they might need for a wide range of careers. The GCSE in Computer Science is seen as most relevant to those young people who may want to work in the technical role.

The current computing curriculum is more focused on the narrow needs of the digital economy rather than informing young people about the wide range of ways digital technology is used in a wide range of careers and job roles. In the same way that mathematics and science are not only relevant to those who will pursue careers in these fields, the premise of the computing education could be (but is not currently) to prepare young people to live successful lives within a broad understanding of a digitised economy. In addition, the digital economy the young people are being prepared for is no longer the most relevant or current.

7.2.4 The Computing Curriculum and the Digital Economy

Central to the curriculum is the digital economy. As the school subject that is most directly concerned with the use, understanding, and control of digital technologies, the computing curriculum is shaping young people's views, understandings, and anticipations of the digital economy. The young people involved in this study had a mixed understanding of the digital economy. While the computing curriculum has the opportunity to help young people to build up a better understanding of the digital economy, this does not seem to be happening currently. Computing lessons are more focused on specific concepts or skills rather than how those concepts or skills may be more broadly applied.

The following recommendations are derived from the data collected for this thesis. Central to these recommendations is the goal for the computing curriculum to meet the needs of both the UK's digital economy, as proposed by Livingston and Hope (2012), and to better meet the needs of a wider range of young people, not all of whom will end up with careers in the 'digital economy' but whose economic future will still be highly impacted by digital technologies.

Recommendations

1. In order to serve the needs of the digital economy, the computing curriculum will need to be developed through an understanding of the digital economy and should be deliberate about communicating this understanding to the young people. (Section 7.2.1)

2. Computing education, if it is to engage and inform young people about the digital economy, will need to engage with emerging and new technologies in order to give young people the tools they need evaluate and make decisions about what technologies they use and how they use them. (Section 7.2.2)

3. In order to equip young people to make better decisions about the future, the computing curriculum should inform young people about the potential impact of different kinds of technology. (Section 7.2.3)

4. Computing education is currently focused on the needs of the narrow digital economy and this does not seem to meet the needs of many pupils. It may better meet pupils' needs if it informed young people about the wide range of ways digital technologies are used in a wide range of careers and job roles. (Section 7.2.3)

7.2.5 Digital Economy.

Table 8 - Digital Economy Analytical Framework:

Theme Title	Aims from the Curriculum related to theme	Definition developed from literature	Pupils understanding /response to theme	Teachers Understanding /response to the theme	Response of the Experts in January 2020
Digital Economy – *How do KS3 pupils and teachers understand the digital economy and broader digital world and how are the pupils understanding being shaped by the delivery of 2014 computing curriculum?* ***Selective codes used:*** ***People:*** *- Naming computer scientists.* *- People of the Digital Economy* **Describing the digital world** *- Utopia vs Dystopia* *-Feeling of anxiety, overwhelmed and … pressure to keep up* *-Moving Too fast* *-What I want to do with my life* *-Positive experiences & Negative experiences* *-How using Computers has helped me.*	Much of the rhetoric (see Chapter 2) regarding the new curriculum related to developing skills for the digital economy, although digital economy is not directly mentioned. "Computing also ensures that pupils become digitally literate – able to use, and express themselves and develop their ideas through, information and communication technology – at a level suitable for the future workplace and as active participants in a digital world."	Digital Economy refers to the process of digitisation and the growth of the importance of the big data, Internet and World Wide Web to business. If discussing young people 'working in the digital economy', this relates to working in a sector that could not exist without this digitisation and Internet access. While other jobs may rely on the digital economy to operate, in this thesis they are not necessarily considered directly part of the digital economy.	Do not have a clear idea about the digital economy Want to be prepared for a broader digitised economy, but do not see how what they are learning related to the skills needed for broad range of jobs. Have a range of concerns about the technological changes, that are not being addressed by the curriculum. Some of the more technical aspects of computing are in fact making young people think twice about having careers which need more use of computers Know the skills they learn in computing are important, even if they don't really know why.	Piecemeal and inconsistent knowledge of the 'digital economy'. Little sense of how the curriculum could be relevant to how the young people use technology – while the computing curriculum does seem to serve young people who want to pursue career in Computer Science, it does not seem to serve the majority of students who are less likely to have a Computer Science related career. The curriculum does not seem to be preparing young people for a 'broader digital world' or digital economy.	Young people continue to question the purpose of, or how they will make use of the skills included in the curriculum. Teachers do not have enough knowledge regarding the digital economy. The curriculum has too narrow concept of the digital economy. Some aspects of the curriculum are not relevant. While one of the arguments made for the computing curriculum was to increase the number of young people taking up Computer Science, a better argument might have been that computing is useful in a wide range of disciplines. There are aspects of the curriculum that are not relevant to most jobs, and young people have little sense of what computer science is or have diverse role models of who can be successful in it.
Conclusions	One of the largest challenges for the curriculum is that, while it aims to prepare young people for the digital economy and digital world, there is little sense of what this might be. The curriculum may be preparing young people for a narrowly defined digital economy, but they are not necessarily being prepared for a broader digital world. Furthermore, there is a question about how young people's understanding of the digital economy is being impacted by the curriculum – the experience of the young people and the teachers seems to be that their understanding of the digital world and digital economy is not being developed substantially by the computing curriculum.				

7.3 Digital literacy

Being digitally literate is essential to success in the highly digital world that the young both live and work in. The computing curriculum states:

> *Computing also ensures that pupils become digitally literate—able to use, and express themselves and develop their ideas through, information and communication technology—at a level suitable for the future workplace and as active participants in a digital world.* (DfE, 2014, online)

The key to achieving this aim is building up an understanding of what it means to be digitally literate. The curriculum uses a limited definition of digital literacy to mean "able to use, and express themselves and develop their ideas through, information and communication technology" (DfE, 2014, online)

Based on the literature explored, this thesis has taken a stance that digital literacy is made up of three aspects that broadly involve use of technology, the cognitive skills of understanding digital information, and the social-emotional skills to interact with others in digital environments (Aviram & Eshet-Akalai ,2006, p. 94; Ng , 2012, p. 1067).

The world in which these young people live, work, and play has been radically transformed by the advent of ubiquitous digital networks (Livingston & Sefton-Green, 2016, p. 5). From the interviews explored in this thesis, the young people do not necessarily feel they have or can demonstrate that they have the skills needed to navigate this transformed world.

7.3.1 What Do We Want…. ICT Skills… When Do We Want?

The young people could see the relevance and value of IT skills. Many of the skills associated with IT and ICT could be taught in a cross curricular manner as Woollard (2018) highlights:

> *An analysis of the national curriculum document quickly reveals that it is very thin on ensuring that learners have a rounded and contextual understanding of the values of technology. We should be lamenting the failure of ALL the subjects of the national curriculum to embrace the opportunities of technology in the teaching of their subjects.*
>
> *Technology and information technology is fully integrated into and pervasive across all our lives, and the national curriculum for the 21st century should have reflected that integration and pervasiveness. Instead, the subject has been siloed. It is taught in computing and it is taught nowhere else.* (p. 23)

The young people interviewed valued the ICT skills they had learned; they could see how using office type software was key to success in the world of work (Sections 5.3.1 and 5.4.3). The subject content for computing leaves a wide scope in terms of the usage of specific software or skills. This is in contrast to being highly specific in terms of computational and Computer Science skills which are included—Binary numbers, Boolean logic, two programming languages, and understanding the algorithms for sorting and searching.

While there is theoretically potential for ICT skills to be included, either in computing lessons or across the curriculum, the data indicates that the more complex and more specific aspects of the computing curriculum are dominating the time. The young people in this study all received only one hour a week which is in line with a national reduction in the amount of time being devoted to computing education in England, according to the 2018 Roehampton Annual Computing Education Report (Kemp & Berry, 2019):

- *The number of hours of computing ICT taught in secondary school dropped by 36% from 2012 to 2017. Across the country, KS4 saw 31,000 fewer hours taught per week, a 47% decrease. (p. 2)*
- *In Key Stage 3 (KS3), the time given for computing dropped from an hour in 2012 to just over 45 minutes in 2017, despite the marked increase in the demands of the national curriculum at this level.* (p. 2)

With such limited time given to a single subject that is intended to include such a wide range of topics, a degree of prioritisation must be made. From the general perspective of many of the students involved in this study, that prioritisation is not correct.

The computing curriculum cannot serve the needs of both ICT and Computer Science in the time it is being allotted. For many of the young people involved in this study, they would rather use that time to learn the ICT based skills, though really, they do value both ICT and computing (Section 5.3.1). For the young people who do not see their future as involving a technical career, it is hard for them to see the need for the Computer Science skills they are learning (Section 5.4.2).

It seems that, currently, the priority is given to Computer Science as a way of leading to ICT; this is the opposite of what the young people want and what reports such as "Shut down or restart" (Royal Society, 2012) recommend.

7.3.2 Critical Thinking and Media Literacy

Many of the young people involved in this study did not see how computing could be an avenue for creative endeavours. The young people involved in this study could not see the creative aspects of their computing lessons, and did not feel that computing was a particularly creative subject. Using the three-fold nature of digital literacy presented in this thesis, media literacy and critical thinking are an essential part of being digitally literate.

If the aim of the computing curriculum is to ensure that all young people are digitally literate then, in line with Preston et al. (2018, p. 70) who asserted that “digital literacy is the ability to find, evaluate, utilise, share, and create content using information technologies and the Internet”, the ability to both evaluate and create content are core skills. There was little evidence that the young people had considered that being able to evaluate content was something they should consider as part of their computing lessons. On the other hand, in various ways, they reported consuming a wide range of digital content and even raised questions about this content in the interviews (Section 5.3.1). This is consistent with the findings of Livingston and Sefton-Green (2016, p. 5). Glister (1997, p. 135), in one of the first works on digital literacy, raised questions about the need to be able to contextualise content, warning that one of the problems of hypertext is that it was not always possible to judge the validity or usefulness of every link clicked. Based on the data collected, these very skills of contextualisation are missing from the current delivery of computing.

The computing curriculum has the stated aim that students

- *are responsible, competent, confident, and creative users of information and communication technology.* (DfE, 2014, online)

There is little guidance in the subject content on how this aim is to be achieved. Teachers reported having access to various resources to support the delivery of the Computer Science aspects of the curriculum, such as computational thinking and programming (Section 6.4). There seems, however, to be relatively little support in regard to the critical thinking, cognitive, and creative content creation aspects of digital literacy.

7.3.3 Complex Digital Social Lives … Require Digital Social Skills

The young people involved in this study reported having rich digital social lives. This is in line with the findings of Livingstone and Sefton-Green (2016, p. 32). While the young people were aware of and, in some cases, had had negative experiences online, they also reported the positive advantages of living digital lives. Whether this was having friends and contacts all over the globe, taking part in events (such as flight simulations), or deepening their engagement of politics, these young people were taking advantage of the social potential of talking to other people online (Section 5.3.2). As Livingston and Sefton-Green (2016) found in their study, "the young people's small social worlds were not simply those of traditional British society" (p. 83). While one might assume this would be the case for Livingstone and Sefton-Green's (2016) study conducted in London, there was less visible diversity overtly apparent in the participants included in this thesis and their digital social worlds spanned the globe including San Francisco, the Philippines, France, Portugal, and Kent (Section 5.3.2). While digital socialising enabled the young people to have contacts across the globe, this is not to say that they drew a sharp distinction between their online and offline relationships. This also aligns with the findings of Livingston and Sefton-Green (2016) who stated:

Our account of peer communication suggests that young people neither sharply distinguish online from offline nor find this distinction irrelevant. Rather, they are highly attuned to the particular affordances of social networking sites—the conditions of visibility, connectivity, discoverability, amplification, and most importantly privacy. (p. 105)

In contrast to the findings of Livingston and Sefton-Green (2016), these young people were quite aware of some of the risks of social media. They were aware that there could be real life consequences for what they did or said online, as some of them had learned from experience.

These young people are having to navigate a complex social world themselves and there is an argument to be made that they are learning these social rules on their own, learning what to say and to whom. They seem to be aware of what could be called ‘basic e-safety’ or the need to keep their private information secret (Section 6.3.3). It seems, however, that these complex social lives go beyond the risk-focused approach implied by the computing curriculum.

The curriculum focuses on ensuring that young people are aware of the risks of an online world. From the interviews conducted, it seems some of the young people have learned how to take advantage of the benefits of the rich social environment of the online world while others are not as aware of these advantages.

The data collected indicate that digital literacy cannot be a topic that is limited to just computing. It goes beyond the scope of computing (and computing teachers) to ensure that young people have the social skills needed to conduct digital social lives. This means that teachers of other subjects will need to be well-versed in the affordances, advances, and privacy implications of a wide range of social media platforms.

Based on the interviews with teachers and young people, social-emotional digital literacy does not seem to be currently addressed in the computing lessons beyond limited presentations about the basics of 'e-safety'.

7.3.4 Learning Digital Literacy

Even taking the most limited definition of digital literacy, there is little evidence from the interviews conducted that the young people felt they were learning anything that was ensuring that they were digitally literate. The young people did report that they had learned many of the basic skills of digital literacy in primary school. However, for these young people, that was not part of the current curriculum.

If computing is to continue to include digital literacy and continue to aim to ensure that all young people are digitally literate and "are responsible, competent, confident, and creative users of information and communication technology" (DfE, 2014, online) then time needs to be devoted to this endeavour.

The skills that are core to digital literacy, do not necessarily need to be based within the computing lessons, but the fact remains that digital literacy is included in computing (DfE, 2014) and that these skills have been siloed into computing without appearing in other subject areas (Woollard, 2018, p. 23). These skills are too essential to not be taught, both in terms of the views of the young people and the needs of the young people.

Based on the evidence from both young people and teachers, this thesis presents the following recommendations:

Recommendations

1. Teachers across the curriculum should be provided with more CPD in regard to digital literacy. While the curriculum states that "the core of computing is Computer Science" (DfE, 2013, online), the core competency of living in a digital world is digital literacy. This training should include the affordances, advances, and privacy implications of a wide range of social media platforms. (Section 7.3.1)

2. Digital literacy includes digital content creation and content consumption. Resources should be created that support teachers in teaching young people the critical skills to be responsible consumers and responsible creators of digital content. (Section 7.3.2)

3. Young people need to be having deeper discussions about the social skills needed to navigate a digital social world. This should go beyond the limited scope of 'e-safety'. Young people need to learn how to keep themselves safe while, at the same time, leveraging the benefits of leading digital social lives. (Section 7.3.3)

7.3.5 Digital Literacy:

Table 9 - Digital Literacy Analytical Framework:

Theme Title	Aims from the Curriculum related to theme	Definition developed from literature	Pupils understanding /response to theme	Teachers Understanding /response to the theme	Response of the Experts in January 2020
Digital Literacy *Do KS3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?* ***Selective codes used:*** ***Social Media*** *-Social media platforms you use* *-Other people online* *Me Online* ***Online Communities*** *-Friends in far places* *Part of something bigger* **Work vs. Leisure** *-Need ICT for work* *Need CS/computing for work* *-I am learning the skills I need* *-Using computers in the future* *-What are computers for* *-How much time do you spend using computers* **Knowledge and Skills specific** *-Things we need to know and are learning* *-Need to know but are not learning* *-Why are we learning this* *-Things we are learning … but really don't need to* *-Fixing stuff*	Curriculum Aims: The National Curriculum for computing aims to ensure that all pupils: -can evaluate and apply information technology, including new or unfamiliar technologies, analytically to solve problems -are responsible, competent, confident and creative users of information and communication technology.	This thesis follows a three-fold understanding of digital literacy: The first aspect is that it is fundamentally about using digital tools. The second aspect reflects on the information those tools give one access to, thinking critically about information, content and how that information and content has been communicated. The third aspect is about how one uses digital tools to communicate and connect with others on a social and emotional level.	Do not feel they are being taught to be digitally literate. Did not talk about learning how to evaluate either technology or content. Would like to be learning to be competent users of digital devices, but they don't seem to be gaining these skills. Live rich digital social lives, but the social-emotional aspects of digital literacy are not currently included in the curriculum, potentially leaving young people without the skills they need to navigate the social world they are immersed in.	Want to be teaching more digital literacy but the greatest challenge they face is a lack of time. For the most part the teachers see digital literacy as important but find it hard to devote enough time in computing lessons to digital literacy while also ensuring the young people learn the computing/ Computer Science skills. Understanding of digital literacy is fairly limited. While the ICT curriculum does not seem to have been kept up to date with digital literacy, computing seems to have been more of a pivot than an update.	The experts felt the social media technology has developed significantly since the implementation of the curriculum, meaning it missed the importance of digital literacy. However, cross curricular teachers are beginning to see the importance of knowing digital literacy. While some young people are digitally literate, others continue to not have these skills. The experts agreed that digital literacy is a foundational skill but current approaches do not seem to go beyond a basic level.
Conclusions	The young people did not seem to feel they were being taught to be digitally literate, both in line with the aims of the National Curriculum and the broader three-fold definition of digital literacy. If the young people are to learn to be 'digitally literate' through the computing curriculum, teachers will need more time to deliver the skills of digitally literacy, but also the term 'digital literacy' needs to be updated and re-examined to reflect better the world in which the young people live.				

7.4 Computational Thinking

Much of the focus on the change of curriculum in terms of computing was to move from what was felt to be too much of a focus on IT/ICT skills to a curriculum that was focused on the skills of computational thinking and the academic discipline of Computer Science. The curriculum states, “A high-quality computing education equips pupils to use computational thinking and creativity to understand and change the world” (DfE, 2013) It continues:

> *The core of computing is computer science, in which pupils are taught the principles of information and computation, how digital systems work and how to put this knowledge to use through programming. Building on this knowledge and understanding, pupils are equipped to use information technology to create programs, systems and a range of content.* (DfE, 2014)

The move from ICT to computing has been documented as being a move from a curriculum focused on the use of specific technologies to young people having and understanding how computer systems work. Computational thinking is framed as core to teaching Computer Science and is also core to the computing curriculum.

This thesis has investigated young people’s interpretations and understanding of computational thinking. However, the question remains that, regardless of their understanding of the concept, are they learning how to apply it? The following discussion will look first at the young people’s understanding of computational thinking, their views on the value of learning Computer Science, and, finally, the data regarding learning to program (each of these sections reflecting the three different models of computational thinking, Section 3.4.2).

7.4.1 Answer: What is Computational Thinking?

Core to this thesis is the question whether young people understand computational thinking. Depending on their understanding of computational thinking, young people should be able to take these skills and use them in other areas of their lives. On the other hand, if computational thinking is a way of thinking that is specifically useful in Computer Science, then young people's understanding of Computer Science should be investigated (and will be in the following sections). Many of the young people involved in this study had limited knowledge and understanding of computational thinking. Generally, they had not heard the term (prior to the interviews) and had not been given a definition. They did, however, come up with a number of definitions and interpretations of the concept within the interviews.

If young people are expected to be able to apply computational thinking, they should have an understanding of what computational thinking is. While new materials for teachers are valuable resources, the lack of clarity towards computational thinking in the curriculum itself leaves a great deal of room for teacher interpretation. Young people have a limited understanding of computational thinking and they do not see the value of much of what they are learning in their computing lessons (as they cannot see how to apply the concepts more broadly). Computational thinking could be a way of engaging young people, who may have little interest in futures in computing, in computing lessons if they can see how using the logical reasoning skills could be valuable in range of topics.

7.4.2 So What is the Deal With Computer Science

The 'Shut down or restart' report states that Computer Science is "the rigorous academic discipline, encompassing programming languages, data structures, algorithms" (Barnes & Kennewell, 2018, p. 38; Royal Society, 2012, p. 5).

The young people had little sense of the different contexts in which they may use Computer Science in the future; they could not see how what they were learning would be relevant to them (Section 5.4.2). These young people had a limited idea of what Computer Science was or what the core knowledge of Computer Science was. While they had learned about Boolean logic and binary numbers, how to apply them and how to make use of this knowledge was more difficult to understand.

The teaching of Computer Science has a short history: there is less than a 50-year history of teaching algorithms and people have been teaching programming to under 14-year-olds for less than 20 years (Woollard, 2018, p. 17). Where the techniques of teaching a subject such as mathematics or science may change on an ongoing basis, there is an established core knowledge (or CPK, content pedagogic knowledge) that does not change. This is not the case for Computer Science as specifically taught to a general Key Stage 3 population (Woollard, 2018, p. 18).

7.4.3 Get with the Program…. Tell Me Again Why We are Teaching Programming

None of the research questions in this thesis focus directly on computer programming. However, Section 2.4.5 demonstrates that writing computer code was seen as an essential part of computing and the 2014 curriculum. Section 3.4 looked how, within the academic literature, several authors (Ahmend et al., 2010, p. 44; Brennan & Resnick 2012, p. 3; Lye & Koh, 2014, p. 51; Brennan and Resnick 2012, 3) indicated that programming is essential for teaching computational thinking. The Key Stage 3 curriculum also requires that all pupils should be taught to:

- *use two or more programming languages, at least one of which is textual, to solve a variety of computational problems; make appropriate use of data structures [for example, lists, tables or arrays]; design and develop modular programs that use procedures or functions* (DfE, 2014, online).

Programming came up repeatedly for both teachers and pupils in this research, both in terms of its role and importance for the pupils' understanding and futures.

Wider literature argues that creating digital artefacts can be a powerful learning experience for all young people and prepares them for far more than just a career in computing (Savage & Csizmadia, 2018, p. 145). The inclusion of computer programming in the computing curriculum was greeted with a great deal of anticipation as it would give young people control over their digital world (Barnes & Kennewell, 2018, p. 39).

However, Woollard (2018), warned that a rush to focus on code might be a mistake as it had been particularly problematic for teachers with little background in computing. Coding is generating a number of problems for teachers new to computing and:

> *some are perhaps conflating the idea of computing and computer programming. Many people think that computer programming is at the heart of computing when in fact it is better to think computational thinking lies at the heart of the subject*. (Woolllard, 2018, p. 17).

Woollard (2018) went on to warn that:

> *The teacher merely knowing how to program is not sufficient; there must also be the ability to teach programming, taking into account previous levels of knowledge, background and experiences. Perhaps the challenge facing many teachers is that they will have to teach programming without themselves knowing how to program?* (p. 18)

The interviews with teachers for this study showed that, while teachers with a Computer Science background were well versed in a wide range of programming languages, other teachers were not as sure footed in the area of programming (Section 6.4.4). For teachers still gaining their own confidence with programming, it is even more important that "they must fully appreciate why we are teaching programming and why we use particular strategies and resources for teaching programming" (Woollard, 2018, p. 18). Passey (2015, p. 42) argues that programming can be a powerful teaching tool for teaching problem solving and creativity, but only if it is not taught through didactic programming activities. However, from the interviews with teachers for this thesis, teaching programming at the Key Stage 3 level is not straight forward and finding this balance is not always easy (Section 6.4.3). This is not to argue that programming should not be taught, but that when not taught in a purposeful context, it may not have the desired benefits for pupils.

Teachers need to receive appropriate training, not just in using code but also in having a deep understanding of programming. If young people are to learn a minimum of two programming languages, then teachers should have a far more expansive repertoire of programming experience.

Programming is dominating much of the time allowed for computing in Key Stage 3 (Section 6.4.3), especially if young people must have an understanding of more than one programming language. This time commitment is incompatible with the current breadth of the computing curriculum and the limited resources available. Given this, the question remains as to whether programming is more valuable than other areas of the curriculum?

7.4.4 Thinking about Computational Thinking?

The computing curriculum was heralded as introducing young people to Computer Science and giving them the skills for computational thinking and computer programming. There is no question, based on the data collected here, that, in some ways, this has been accomplished. Not only does the curriculum itself focus heavily on Computer Science, but the young people reported that they are clearly being taught programming, some Computer Science, and may be building an understanding of computational thinking (though this is less clear). There is still work to be done on understanding the best way of teaching these topics to children of this age.

The ICT focus of the previous curriculum was linked to the reduction in number of students studying Computer Science at a higher level (Woollard, 2018, p. 21). The computing curriculum better reflects the skills and knowledges needed for Computer Science far more than the ICT curriculum could. This does not necessarily mean that the students are more engaged in what they are learning.

Woollard observes that “many pupils are not inspired by what they are taught and gain nothing beyond basic digital literacy skills” (Royal Society, 2012, p.5, cited in Woollard, 2018) might in fact shift in the near future to become “many pupils are not inspired by what they are taught and gain nothing beyond basic coding skills” (Woollard, 2018, p. 22). This observation reflects the data collected through this thesis: many young people felt they were gaining nothing beyond basic coding skills and those who were interested felt that it was not enough while others felt it was far too much programming (Section 5.4.3).

Many of the young people interviewed had not heard the term “computational thinking” prior to the interviews or had not thought about how to apply it (Section 5.4.1). This was also reflected through the interviews with teachers. The teachers recognised that “computational thinking,” while important, may not be accessible to every pupil (Section

6.4.1). The teachers raised a number of times that the current focus of the curriculum seemed to overemphasise the "programming" side at the detriment of things such as digital literacy (Sections 6.4.2-3) and that teaching programming was taking up the most time.

It seems that digital literacy, computational thinking and Computer Science (as a discipline) are taking a back seat in the curriculum compared to basic coding skills (Section 6.4.3). While one of the purposes of the curriculum was that young people would have a better understanding of Computer Science, the understanding of Computer Science the young people are gaining is narrow.

While Computer Science has an important role to play in secondary education, it is not a replacement for ICT. An attempt to mix ICT and Computer Science has involved sacrificing many of the core digital literacies of ICT and omitting many core aspects of Computer Science.

Recommendations.

1. If young people are expected to be able to apply computational thinking, they should have an understanding of what computational thinking is and be able to see the value of what they are learning in their computing lessons for their future lives. Computational thinking should be embedded in the curriculum and the curriculum should not leave a great deal of room for teacher interpretation. (Section 7.4.1)

2. If Computer Science is the core of computing, then it is advisable to teach the fundamental knowledges of Computer Science explicitly. As digital literacy and even computational thinking can be applied to a range of futures, young people have yet to see the value of the Computer Science knowledge they are learning. (Section 7.4.2)

3. Justifications of teaching programming must be clear to teachers and students. Teachers need to receive appropriate training, not just in using code but also in having a deep understanding of programming. If young people are to learn a minimum of two programming languages, then teachers should have a far more expansive repertoire of programming experience. The push to have more computing teachers with a background in Computer Science is essential and should continue. (Section 7.4.3)

7.4.5 Computational Thinking:

Table 10 - Computational Thinking Analytical Framework:

Theme Title	Aims from the Curriculum related to theme	Definition developed from literature	Pupils understanding /response to theme	Teachers Understanding /response to the theme	Response of the Experts in January 2020
Computational thinking *What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?* ***Selective codes used:*** **Computer Science** -thinking like a computer scientist key outlier -Things about Computer Science that we just aren't learning **Computational Thinking (CT)** -computational thinking? -Problems with CT **Thinking like a computer scientist** -what makes you good at (CT) **What about programming** -Personal coding -The best thing about coding Is it useful? -Is this all there is? -Careers in coding -Copying down from the white board kind of coding	Curriculum Aims: The National Curriculum for computing aims 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	Three approaches to CT can be identified from literature. The general problem-solving approach, where computational thinking is general skill which can help a broad population solve problems while using computers The computational model approach, which focuses on the formulation of the problem so that solution can be expressed by a specific model of computation. The programming approach which presumes that the process of computational thinking requires the solution to be expressed within a programming language.	May be meeting the curriculum aims, but without context or understanding. Are unfamiliar with the term 'computational thinking' and seem to not have an understanding of how the content they are learning relates to problem solving. Are learning about Computer Science and programming but aren't seeing how these fit into a form of problem solving. They see the value of the 'computational logic' but aren't necessarily sure how to apply this to problems in the real world.	Some of the challenges of teaching computational require addressing the question of what the purpose of teaching 'computational thinking' is. There was a lack of clarity as to what exactly was meant by computational thinking. This was exacerbated by not all teachers having an in-depth knowledge of the academic discipline of Computer Science and therefore not able to fully contextualise computational thinking within the rigorous academic discipline. The largest challenge, in many ways, for teachers was the requirement to teach (two) computer (programming) languages. This takes up a great deal of time and isn't always easy to relate back to Computer Science or even computational thinking	Computational thinking continues to be a challenge for the computing curriculum, and there is still a lack of clarity to what it is or how to teach it. Computational thinking is a key part of the curriculum and it is essential pupils and teacher have a clear understanding of what it is. However, new resources are helping to address this. There continues to be a struggle to recruit new teachers with a computing background or provide adequate CPD for existing teachers and schools are struggling to resource computing. It is essential there is consistency in how computational thinking is taught.
Conclusions	The aims of the computing curriculum indicate that the young people should be learning to use computational concepts to analyse and solve problems and having the practice of writing computer programs to solve problems. The central challenge encountered by the teachers and young people is in ensuring the young people have enough practice and knowledge of programming to be able to write programs that solve problems. While the curriculum would indicate that young people should be learning 'the programming' approach to computational thinking, the understanding of the teachers and young people seems to best align with the 'general problem solving approach' – teachers and young people need a consistent understanding of the concept 'computational thinking'				

7.5 Overarching Discussion.

This thesis has posed the overarching research question:

> To what extent do the young people subject to the English computing curriculum as delivered at Key Stage 3 and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

The 2014 computing curriculum sets out to ensure that young people are prepared for the digital economy and the future digital world by highlighting the importance of computational thinking and digital literacy. Through using a qualitative approach, this thesis has investigated the young people's own interpretations of and experiences with the curriculum and computing, focusing on the key themes of the digital economy, digital literacy, and computational thinking.

It is clear is that all young people will be impacted by the digital economy and all students will need core digital literacy skills. It is also justifiable to argue that all young people need the skills of computational thinking and knowledge of Computer Science.

The young people involved in this study already live in a 'digital world', so they do not see the computing curriculum preparing them for a hard to imagine future. Rather, they have accepted that their lives (and future careers) are being shaped by a wide range of digital tools (Section 5.2.2). This does not mean they do not have questions about changing technology; it actually seems that the questions and concerns they have are specific and informed (Section 5.2.2). They know that they need specific skills and knowledge in order to be successful (Section 5.2.3) and they are looking to the computing curriculum to both prepare and inform them for the future. Computing is informing their choices about the future, even though it is not always in a positive way. Some of the young people reported that computing classes make them feel they can not pursue a chosen career because it might involve to much high-level computing (Section 5.2.3). However, for reasons that should be more fully explored in future research, the pupils seem to look to computing to prepare them to use a wide range of technology; they want to learn to be digitally literate and do not seem to feel they are gaining these skills from the curriculum (Section 5.3). More urgently, the young people are leading rich digital social lives, but it does not seem that ICT and computing historically have covered ‘social skills’ beyond basic e-safety (Section 6.3.2). Based on the literature reviewed in this thesis (Section 3.3.1), these digital social skills are a key component of digital literacy. If these skills are not included in computing, where should they be included?

One of the things that came across most acutely from the data collected is that both teachers (Section 6.3) and pupils (Section 5.3) feel that there are wide range of basic digital literacy skills that are missing from the 2014 computing curriculum. If on no other issue, the lack of these basic skills (such as using and understanding things like office type software) made the young people feel as though they are not being adequately prepared for the future. Many young people, and teachers from other disciplines, still looked to computing to teach these skills (Section 5.3.1).

Are young people learning to thinking computationally? This thesis has explored the term ‘computational thinking’ and found that it is a term that can be used in a range of ways. From the interviews, the young people felt that there may be a ’specialised’ way of thinking in computing and that this was not necessarily something that could be learned—some people were just good at it and hence it could be seen as a limiting factor for some young people (Section 5.4.1). This was a sentiment echoed by the teachers in their interviews (Section 6.4.1). For the young people interviewed in this study, computing was not a subject with creative potential nor was it a subject that could give them tools to solve problems.

What do young people feel they are learning in computing? From both pupil and teacher interviews, the theme that dominated the majority of time in computing lessons was teaching computer programming. Programming could be seen as part of all of the three themes included in this thesis: programming is essential to the digital economy, could be seen as the reading and writing of computing (literacy), and as a component closely linked to computational thinking. Based on these interviews, while programming is dominating the majority of lesson time, it is being taught without context. Programming is being taught as an end in itself rather than a means to an end, while other aspects of computing cannot fit within the time allotted for computing lessons.

7.6 Expert Interviews and Validation

In line with the methodology outlined in Section 4.5.2, three expert interviews were conducted in January 2020 as final part of this research. While the primary purpose of these interviews was to validate the research findings and recommendations presented in this chapter, this was also an opportunity to discuss how computing education had developed in the intervening years between the field work for this Ph.D. (summer 2016 and spring 2017) and the final completion of this thesis (May 2020).

As stated in Chapter 4, determining 'validity' in qualitative research is about considering the relationship between the conclusions and reality (Maxwell, 2010, p. 279). In this case, three experts were selected who had not been engaged in previous aspects of the research and who brought to the research various forms of expertise.

Expert 1 is a regional coordinator for an international organisation which runs extra-curricular coding and computing based activities both in and outside of schools, as well as providing training for educators with regards to computing and related areas.

Expert 2 is the head of IT in a school which is similar to the other schools involved in the study (size, region, rurally based). This teacher has been involved in computing education for a significant amount of time and has been involved in Computing at School since before the new computing curriculum was adopted. This expert had also previously worked within the technology sector prior to becoming a teacher.

Expert 3 is a principal lecture in education and subject lead for computing at a national university. Expert 3 had also been involved in Computing at School since prior to the implementation of the computing curriculum and has continued to be involved in computing education research.

Each expert was presented with the framework (Tables 8-10 above, excluding the 'expert' section) and an abridged version of Sections 7.1 - 7.5, focusing particularly on the conclusions and recommendations. The expert interviews were semi-structured using a loose range of questions.

Overall, all three of the experts commented that they felt there was a great deal in the research which they agreed with. For example, Expert 1 stated, "I found myself nodding along as I was reading". Expert 3 particularly highlighted the value of research into the delivery on the ground of computing, pointing out that there is very little research into what computing looks like when it is delivered in schools. Expert 2 found the research valuable as it reflected their own experiences of teaching computing at KS3, saying that many of the challenges which came out of the research have continued to be challenges for the field.

All three interviews brought up the challenges of continuing professional development (CPD) for teachers teaching computing, this was raised as one of the main challenges of the computing curriculum in the early years of delivery. While there was some feeling that this was being addressed by the recently formed National Centre for Computing Education (NCCE), there was still a great deal of work to do and the impact of the lack of early CPD had had a long-term impact, such as some schools ceasing to deliver computing in any meaningful way (Section 7.3.1). The lack of computing teachers without a Computer Science background was particularly highlighted by Experts 2 and 3. Expert 2 commented that current teacher training did not seem to involve any specific training in IT or digital literacy, meaning that new teachers in all subjects would lack any high-level skills needed to teach digital literacy or IT across the curriculum.

7.6.1 Digital Economy

Expert 1 particularly considered that there was still a struggle with engaging the curriculum with the jobs that could be considered part of the digital economy, leaving the young people to question why they were learning these skills. They agreed with the findings that if the teachers did not have enough knowledge regarding the digital economy, the young people could not see how they would use what they were learning in computing. Expert 3 considered the challenge that, in many ways, the computing curriculum had been developed with too much of a narrow concept of the digital economy in mind, while not thinking about how to meet the needs of a wider range of young people. They pointed out that while one of the arguments made for the computing curriculum was to increase the number of young people taking up Computer Science at the university level, a better argument might have been that:

> *… there are loads of things you could study at university where being able to code may be quite useful for you, obviously any type of numerate activity, maths, physics, engineering, you are going to do some coding in these degrees, and these days there are areas of humanities where this is becoming increasingly important.* (Expert 3)

Expert 3 also felt that there were certain elements of the computing curriculum (such as converting binary numbers to base ten) which were not relevant to many jobs either within or outside of the digital sector.

Expert 2 commented that, as reported in the research, young people continue to have a narrow idea of what Computer Science might look like and are not being shown a wide range of role models of who can be successful in computing.

Expert 3 concluded that CAS had initially called for more of a focus on the "individual, cultural, and social impacts of technology" but this was removed from the curriculum before it was implemented.

7.5.2 Digital Literacy

The digital literacy aspects of the study came up in various ways across the expert interviews. Expert 2 made the point that the digital landscape has changed a great deal since the initial conversations about introducing computing to the National Curriculum. Many of the social media services that the young people use on a regular basis did not exist or were not as prevalent among young people from 2008-2010, and young people (in Expert 2's experience) had not had their own smart phones or the same level of access to the Internet. In Expert 2's opinion this meant that many aspects of what this thesis calls digital literacy (social emotional literacy, for example) were not included in the curriculum or many of the guidance documents produced by CAS.

Expert 1, as someone who delivers training to teachers, reported having seen a shift in interest with regards to digital literacy skills. In the past, non-computing teachers did not see the relevance of these skills; these teachers were now understanding that they needed to learn how to teach young people how to use various software tools. From their work with young people in coding clubs, Expert 1 had felt the young people were learning the technical aspects of digital literacy.

This contrasted with the experiences of Expert 2, who as a computing teacher, reported that teachers across the curriculum continue to not have the digital literacy skills nor are they able to teach them.

> *I totally agree with the thing about digital literacy, but I will also agree, you say somewhere about the staff don't know [digital literacy] - Yeah they don't, at the moment a fair number of the kids are more capable consumers than the staff - without a doubt* (Expert 2).

Expert 2 went on to state that digital literacy is "a foundational skill, that everyone should be learning". This was a sentiment repeated by Expert 3, who felt that in the current delivery of computing in schools, teaching programming (for example, languages such as Python and Scratch) had pushed out the teaching of "being able to get useful stuff done with computers" (for example, making and editing videos). They continued, saying:

> *Everybody should know to use Excel by the time they leave school, or any other spreadsheet. This is a fundamentally necessary skill for so many jobs, teaching included - Broadly speaking it was taught badly in the past but is was taught.* (Expert 3)

While both Experts 2 and 3 talked about young people learning the basics of e-safety they both thought that this was a fairly basic level and did not go into young people protecting their data online or the long-term consequences of a person's actions online.

The nature of being human beings is that we see physical threats, and the danger of online stuff tends to be a long-term marathon rather than a smack in the face now (Expert 2)

Expert 1 echoed the findings, in terms of both digital literacy and digital economy, that these are fast-moving areas and it is difficult for teachers to stay up to date with the latest information.

7.6.3 Computational Thinking

All of the experts interviewed agreed that computational thinking continues to be a challenge for the computing curriculum. They all reported that there continues to be a lack of clarity as to what computational thinking is or how to teach it. They all also agree that computational thinking is a key part of the curriculum and it is essential that young people and teachers have a clear understanding of what computational thinking is.

Computational thinking and the curriculum itself, leaves a great deal of room for teacher interpretation. Yeah because most of them don't know what it is anyway. (Expert 2)

As Expert 1 put it while speaking specifically about computational thinking, young people "are struggling to put into words what they are learning and part of that is because [teachers] are struggling to sell it to them and make it appealing." However, Expert 1 felt that teachers' understanding of computational thinking was improving as the resources and training available to them had improved (though this has happened only recently).

Expert 3 commented specifically on the three approaches to computational thinking and felt that, while pupils were learning about key algorithms such as sort and search, they would not have an understanding of how to apply computational thinking or even what it was. More broadly, they felt that there were not enough teachers with a sufficient understanding of Computer Science in general to teach the subject with depth and rigour.

> *It is there in the KS3 curriculum – understand key algorithms and apply computational thinking, and it is interesting that it is understand key algorithms, this is sort of where we integrate literature, and then we get into the nitty gritty of sort and search - which of course make it onto GCSE specification – they are not the only algorithms that reflect computational thinking – but I suspect many pupils will leave KS3 even if they have followed the National Curriculum seeing those the only ones that really matter.* (Expert 3)

Expert 2 echoed this sentiment, while they recognised that there was (and continued to be) a challenge of providing CPD for teachers. They suggested that there was a greater challenge of recruiting teachers with the right skills and knowledge in the first place, but that it was equally challenging to fund computing (in both staff and hardware) in schools.

Expert 1 commented that many of the teachers who were teaching computing in the early years (as reported in this thesis) did not have a computing background and this resulted lack of consistency in how well computing was and is delivered.

7.6.4 Programming

One of the findings of this thesis was that programming had come to dominate computing lessons at KS3 (Section 7.4.3). Experts 2 and 3 both agreed that this was the case, while Expert 1 reported that the young people they worked with (a self-selecting group who attend coding clubs) reported wanting to learn more programming.

Expert 2 agreed that "teaching programming is time consuming", echoing the other interviews with teachers that, like with foreign languages, learning a programming language takes time and repetition in order for one to become skilled. Expert 3 thought coding had received a great deal of attention during the introduction of the curriculum but that it was important that young people learned how to use programming in an impactful way, using it to solve problems and not in a "'type this in…' now you have written a program" kind of way. They also thought it was essential that programming was connected to the computational thinking aspects of the curriculum. Expert 3 commented that one of the things the research revealed well was that there is a lack of connection between the programming and problem-solving aspects of the curriculum.

While both Experts 1 and 2 also felt the young people learning to write computer programs was an important part of the curriculum, they also both echoed the fact this needs to be done in a meaningful and relevant way.

> *… I mean ICT was swept out, this was swept in and everybody was left going 'whaoo …. Holy crap where did this come from" and there wasn't really… I mean those of us who had been involved in it kind of knew what we were doing, but even I looked at it and thought 'oh my god, this is going to be a mess' … we look at both, we do IT and computing - but that is partly because that is my thing.* (Expert 2)

Expert 2 highlighted that, while programming was important, the fact that it had been introduced at the expense of much of the ICT curriculum was a mistake. That the intention of the CAS when calling for computing to be introduced into the curriculum was always for it to complement much of what was already in place. "And that was never actually intended – that was baby, bath water, sponge, plug, everything and that was horrendous – that was never planned" (Expert 2).

7.6.5 Validating the Research

While all three of the experts felt that the research was a valuable contribution to the field and adequately reflected the reality of computing education, from the conversations with Experts 2 and 3 a number of limitations of the research became clear. Expert 3 specifically pointed out that one of the challenges of knowing what computing delivery looks like in practice is that many schools in the UK (free schools, academies, private schools, and independent schools) are not required to follow the 2014 English National Curriculum. Both Experts 2 and 3 highlighted that one of the main drivers of how computing is taught at the KS3 level is determined by preparing young people for the Computer Science GCSE (an elective subject typically in year 10), and that recent changes to the GCSE assessment may mean that the way in which programming is delivered will change. Finally, all three experts discussed how the delivery of computing at KS2 (while the young people are in primary school) has had a large impact on how computing is delivered in KS3. While there has been a great deal of progress at primary schools, this has taken time.

Through the interviews with these three experts, it seemed that the research presented here presents a valid representation of computing education, aligning with their understanding of both the strengths, weakness, and challenges of the subject in England. Expert 1 commented that the research was “exactly what I was thinking”. Expert 3 not only commented on how the research reflected much of what they already had found, but that the research is a valuable addition to the field as there is little information about how computing is being delivered or how young people are being impacted by it. They continued saying, “the fact that you have gone in there and asked them is tremendously useful.”

7.7 Discussion and Conclusion

This chapter has presented the key findings of this thesis and discussed how these findings address the research questions presented in Section 4.2.3. While the answers to any qualitative questions are never straightforward, by answering the research questions, this thesis has been able to explore how young people are experiencing the computing curriculum and how the Key Stage 3 computing curriculum is impacting on how they make decisions and view the world.

This chapter has also presented the results of three expert interviews used to validate the data and findings. These interviews were also a chance to reflect on the changing nature of the field of study this thesis is concerned with. These experts reflected on the findings and agreed that they were in line with their own experiences, while highlighting a number of interesting observations about the broader context of computing education at Key Stage 3 in the UK.

Chapter 8: Conclusions

8.1 An Introduction to the Conclusion.

The field of computing education and its new focus on teaching Computer Science concepts and skills to pre-graduate learners has developed swiftly over the last several years. The U.K. Government published its curriculum reform in 2013, and the new curriculum (including the computing curriculum) was implemented in 2014. This Ph.D. thesis began in 2015 with the initial field work taking place in 2016, with an attempt to gather early data about the impact of the curriculum on young people.

Over the past 7 chapters, this thesis has examined the computing curriculum in the context of three main themes that informed the creation of the new curriculum. Chapter 2 dealt with a historic view of computing education in England and looked at the emergence of the new curriculum. Chapter 3 examined the academic literature concerning the three themes. Chapter 4 outlined the methodological approach taken to gather data for this project. Chapter 5 presented the data gathered through group interviews with young people. Chapter 6 contextualised the data from young people with data gathered through in-depth interviews with their teachers. Chapter 7 revisited the answers to the research questions, drawing recommendations from the data collected, and validating the thesis's finding with the views of experts in the field.

In line with a grounded theory approach this thesis has yet to put forward a theory or hypothesis which has arisen from the data. While the "storyline" of the thesis is the connection between the themes and the curriculum, within this space there is room to present theories or hypotheses which can be further investigated and considered. More relevantly these are also hypotheses which should inform future computing curriculum development, as they represent the gap between the curriculum and how it is impacting on young people and their teachers.

This final chapter will complete this thesis by first setting out ten hypotheses or theories which can be concluded from the thesis, examining the limitations of this thesis and the broader project (including methodological limitations), discussing possible future work which could expand and deepen the findings, and concluding by looking at this work's contribution to knowledge.

This thesis marks an important point in time covering five years since the introduction of computing to the English National Curriculum. While ICT included some of the elements that came to be included in computing, much was also new. Equally, the computing curriculum marked a change in focus from a curriculum based on specific skills to a curriculum based on broad theoretical and conceptional content. While the new curriculum included changes to other subjects (such as maths and English), the teachers had the subject knowledge needed to deliver the new content. Computing, however, saw the introduction of a new subject that relatively few of the teachers who were required to teach KS3 computing had a background in.

8.2 Developing New Theory and Hypotheses for the future.

This study has applied a grounded theory approach to data analysis which was characterised by working towards theory (rather than from theory), producing theory and hypotheses as a result, instead of as a starting point. This study proposes the following hypotheses or key insights. These should be seen as the key take-a-ways both for future research but also experts and policy makers. These are the key issues that distil the main learning from the project and process of producing the thesis. As computing becomes a more integral part of the education systems around the world, these insights should help build on the experience in the UK more productively.

Digital Economy:

1. Students have little sense about what a career in the Digital Economy might involve and continue to primarily only associate computer science with a very limited demographic. This limits the impact the curriculum can have on increasing diversity in the Digital Economy. (5.2.1 The People and Things of the Digital Economy: What is a Computer Scientist?)

2. Young people are overwhelmed by digital systems, even to the extent of scaremongering. This is due to the lack of understanding of computational systems or knowledge of what is possible and what isn't. This is a major problem for the curriculum, as building understanding of complex systems is the point of science education. (5.2.2 Describing the Digital world)

3. Young people see ICT as more important to their future careers and lives than computing. Similarly, some young people had such a negative experience in computing that they actively aim to avoid computer-centric careers. (5.2.3 Thinking about their own future and future employment)

Digital Literacy:

4. Young people are not learning "creative digital skills" such as animation, graphic design, and video editing. This could have dramatic impacts for industries such as game design and special effects, where the UK could lose its international advantage. (5.3.2 Thinking Critically About Content and Information)

5. Young people are already living digital social lives, yet the current approach to e-safety does not prepare them to navigate this world. The curriculum and schools are failing to empower young people to take full advantage of the opportunities of living digital social lives (5.3.4 Living Digital Lives—Conclusion Regarding "Digital Literacy")

Computational Thinking:

6. Students lack the basics in terms of many of the basic skills and understanding in computing, in comparison to mathematics (for example), and lack a deep understanding of how to use computational thinking and what it is. This could be because teaching computing is still a developing skill or because students have only recently been taught computing from an early age. (5.4.1 Computational Thinking, A General Problem-Solving Skill?)

7. The young people wanted something more similar to ICT training, which they see as more relevant to their future lives and as it is more concrete, easier to think about and relate to. This is at odds with them wanting deeper understanding of digital technology, which requires a more abstract understanding? (5.4.2 An Understanding of Computer Science and the Computational Approach to Computational Thinking)

8. Currently young people are generally only learning a single text-based programming language, which is chosen by each school. They would benefit more from having the experience of switching between languages, and young people receive a more consistent education if a programming language (or

languages) were stipulated by the curriculum. (5.4.3 - What About Programming and the Programming Approach to Computational Thinking).

From Teacher Interviews:

9. As Computing has become a more rigorous, difficult and academic subject, young people (specifically young women) who may excel at and enjoy it at a high level (such as GCSE and A-Levels), are unable to take the subject if it conflicts with other (STEM) subjects they see as more necessary for their future careers. (6.2.1 Understanding of the Digital Economy)

10. As one of the teachers highlights, there is currently a lack of coherence as opposed to a lack of value – there is not currently an underlying theory for computing, which decreases the value young people gain from it - something that could and should be addressed (6.4.4 Final Thoughts About Teachers on Computational Thinking, Computer Science, and Programming)

8.3 Limitations of This Study

While this study has successfully investigated an important topic with regards to computing education by contributing to knowledge in a number of key ways (see section 8.5), the findings, methods, and context have a number of key limitations which will be discussed here.

Limitation of Time and Scope:

1) **Limitation of time**: This study took a methodological decision to speak to young people and their teachers at a specific point in time. A number of key educational texts served as inspirations for this study: *Learning to Labour* by Paul Willis (1977); *Making Modern Lives* by Julie McLeod and Lyn Yates (2006); and *The Class* by Sonia Livingston and Julian Sefton-Green (2016) – all conducted as longitudinal ethnographic studies of the lives of young people. These studies were designed for the researchers to interview the young people many times over the course of a year or longer (in the case of *Making Modern Lives,* research was conducted over the course of a decade). This Ph.D. study was limited by not having the scope to extend the research out over an extended period of time to investigate how the young people's lives were shaped by their experiences with computing.

2) **Limitation of timing**: The English computing curriculum was introduced in 2014. The field work for this study was conducted in 2016, and this thesis is being completed in early 2020.This study has shown that much can be learnt through the investigation of a snapshot from the early days of the implementation of the computing curriculum. As evident in the expert interviews (conducted in January 2020), the teaching of computing has developed over the years. This study has been limited by the fact that it has concerned itself with a fast-moving area of study, and that as substantial piece of research takes time to complete, by the point of publication, the world as described in the research may not fully represent the world as it may exist now.

Limitations of Geographic Location and School Types:

3) **Limitation of all the sites being in a single region**: The three sites of research for this project were all located in the North-West of England in rural communities. These sites were selected as young people from these types of locations are often excluded from research with regards to computing education. While this means the research may add an important voice to this discourse, it also means that the discussion and conclusions presented in Chapter 7 are based on this limited sample and may not hold true for situations outside of this context.

4) **Limitation of schools in rural isolation**: One of the aspects of rural deprivation and discrimination is a lack of opportunities for training and recruitment for schools and businesses in these areas. While this study focused on rural schools, the teachers in this study may not have had the same opportunities to develop their skills had they been in an area of greater population. This could particularly be the case in the area of digital economy; the businesses based in digital economy are often based in more highly populated areas. The school communities involved in this study may not have the same opportunities to interact with companies that are part of the digital economy as school communities based in cities (though this was discussed in the expert interviews). By only engaging schools in rural areas in this study, it was not possible to compare or understand how rural schools may compare to schools in more populated areas.

5) **Limitations of the English computing curriculum**: This study has aimed to look specifically at how the computing curriculum (as part of the English National Curriculum) impacted on students. This curriculum is only required for state run schools in England. There are many types of schools (private schools, free schools, academies) which are not required to deliver the National Curriculum. It was beyond the scope of this project to look at how computing was taught in other types of schools.

Limitations of Methods:

6) **Limitation of conducting qualitative interviews with young people**: Within education, there is great quantitative data available in the form of test scores, demographic information, student achievement, and outcomes. While this study was looking at young people's experiences with the computing curriculum, quantitative data could have added an important insight into the achievement of young people through the curriculum. By only conducting qualitative research for this study, it was only able to look at the socially constructed reality of the young people. Young people (by the nature of being young) have limited perspectives and may not be able to understand the value of what they are learning, how they will use what they are learning, or how what they are learning fits into a greater context. The young people may not have been in the best position to answer questions with regards to their own learning or education. They may not be in a position to answer whether or not they have learned a particular topic. Such limitations were explicitly countered by conducting the additional teacher and expert interviews.

7) **Limitation of analysis**: The analysis of this research was conducted by a single researcher using a grounded approach to coding data. There are limitations to this approach to data analysis. First, this method of coding data is based on making initial subjective judgments about the data. This limitation can be exaggerated in cases where the research was conducted by the same individual, and can allow the researcher's own biases to be compounded and prohibit them from being 'checked' by a third party. A further limitation is that, while coding data can be useful for analysing large amounts of qualitative data, it requires segmenting data from context and can mean that data loses contextual meaning, or that a 'big picture' or meaning or trend is not seen. Finally, there can be difficultly with this method of analysis with 'group interviews', such as in this study, as it is difficult to follow a single individual's train of thought or pattern throughout the full interview, hence failing to fully appreciate that individual's views or perspectives.

8.4 Potential Future Work

In light of the limitations discussed, this thesis presents the following potential future work to build on the findings of this study. Computing education continues to be a developing discourse with important impacts on the world, and future work would continue to explore the ideas and discussions raised both by the research questions and the subsequent discussion.

1) Longitudinal study: This study was only able to interview the young people once and was not able to observe how the students' answers correlated with their future outcomes. Following in the footsteps of the previous studies, a longitudinal study into computing education could look at how students' understanding of digital economy, digital literacy, and computational thinking played out as they get older. Specifically, it would be valuable to understand how computing education impacted students' choices and outcomes on a long-term basis.

2) Follow up study: This study looked specifically at computing education during 2016. The teaching of computing has developed since this point and many of the forces that shape computing education at Key Stage 3 have also evolved. It would add greatly to the findings of this study to return to the sites of study and interview current Key Stage 3 pupils and their teachers. While the expert interviews provided some of this insight, the spirit of this study was to hear specifically from young people about their experiences with computing.

3) A broader, more inclusive approach to the research: This study was limited by scope; only looking at rural schools in the Northwest of England. Future research should look at a broader range of schools to compare different approaches to computing that are used in different parts of the country, places with different relationships to cities, and looking at a wider range of types of schools. Anecdotally (based on interviews and conversation with experts and teachers), many schools in England (which do not need to follow the National Curriculum) either continue to teach something more similar to ICT or have ceased to teach either computing or ICT. While ongoing research by the University of Roehampton reveals that computing education appears to be on a decline—both in time allotted to it and schools offering a GCSE/A level in the subject—(Kemp & Berry, 2019), p. 1), this not been followed up with qualitative research with either young people or teachers. Future work should continue to use a qualitative methodology to broaden the existing qualitative work on the state of computing education in the UK and around the world.

4) Mixed methods approach to computing education: Because qualitative and quantitative research in computing education both add a great deal to the field of computing education, a mixed methods approach to research could be valuable to this field as it could allow the researchers to see correlations between qualitative and quantitative results. For example, do students with high test scores in computing feel it meets their needs, do students with lower scores want to be learning more digital literacy, is computational thinking being tested effectively? Does an understanding of computational thinking correlate to higher test scores in other areas such as mathematics? A future mixed methods research project in this area could have significant impact in reframing the findings of this thesis.

5) A study with a larger team: One of the main limitations of this project was that it was entirely conducted by a single person. A follow-up project with a larger team would be able to cover more schools across a greater geographic area. Having a larger team would also make it possible to conduct a more rigorous analysis, avoiding the danger of bias both in the collection and the analysis of the data.

8.5 Contribution to Knowledge and Conclusion

This thesis has examined the impact of the 2014 English computing curriculum on pupils at Key Stage 3. In order to answer the research questions, over 20 hours of interviews were conducted with 54 young people, 9 teachers, and 3 experts in the field of computing education. This research project used a qualitative approach to investigate the overarching research question:

To what extent do the young people subject to the English computing curriculum as delivered at Key Stage 3 and their teachers, feel it prepares young people for a digital economy and the future digital world, specifically in terms of being digital literate and being able to think computationally?

Chapter 7 looks more specifically at answering this research question and the subsequent three sub questions. Like the research questions, the answer to this question is not simple or straightforward and has been developed through a deep understanding of the background of computing education in the UK (Chapter 2) and relevant literature (Chapter 3), then drawing together the data from both young people and their teachers (Chapters 5 and 6). The data and conclusion presented in Chapter 7 then were validated through expert interviews (Section 7.6) and, over the course of this chapter, the limitations of this study and potential future work have been outlined.

In conclusion, this study has contributed to the knowledge of field of computing education in the following ways:

1) Answering the research questions: The research question and sub-questions raised important issues with regards to the specific delivery of the computing curriculum in England, holding up the key concepts as expressed in the curriculum and surrounding documentation, and putting under scrutiny the impact of these concepts in young people. This thesis has contributed to the knowledge by examining to what extent the ideals of the curriculum have impacted young people in practice.

2) Literature Contribution: While other studies and reports have also substantially looked at the areas of digital literacy and computational thinking, the literature review for this study developed a new way of understanding of digital economy by examining the digital economy in stages (see Section 3.2.2). This contributes to the field of computing education by allowing computing education as it has developed to be seen within a broader context of the digital economy, as well as how the skills and knowledge that are taught (or not) within computing education relate to a greater or lesser extent to the technological developments of the digital economy. The classification of descriptions of computational thinking was also flagged within the expert interviews as being a valuable contribution to the field. This new way of framing the digital economy is a substantial contribution, not just to the field of computing education, but to any number of areas that deal with the topics of the digital economy. This thesis found that, while the term "digital economy" has been used in academic literature for several decades, the term's meaning has been shifting over time. By considering the digital economy in phases, it allows researchers to understand how past literature impacts contemporary study while also allowing space for future work looking at new technologies and the impact they may have on the economy.

3) Methodological contribution: Few studies of computing education have taken the approach of examining young people's qualitative experiences of the subject. By using group interviews, this study was able to look at how young people's view of the world and an academic subject are shaped by how that subject is delivered. The young people interviewed for this study demonstrated that not only was their view of computing shaped by their computing lessons, but that their understanding of their future lives, the digital economy, and their potential future careers were also affected. Based on this study, future work can use a similar methodological approach to look at other aspects of computing or education in general.

4) Developing a snapshot of the delivery of computing in 2016: Through interviews with young people and their teachers, this study looked at what the delivery of computing looks like in practice across three schools. This is one of the few studies to take this approach, looking at both the qualitative experience of young people and teachers. Computing was a newly introduced subject into the English National Curriculum, and England was one of the first countries to include computing in a statutory National Curriculum. By documenting what this delivery looked like in the early years of implementation, this study allows the future work to take into consideration how this subject develops and is delivered to both England and across the world.

While future readers may find other valuable contributions from this study, the above four contributions establish why this study has been worthy of doctoral-level research constituting a substantial independent research project which establishes new knowledge in the world, creating a new space for future research to further investigate the phenomena explored throughout.

Table 11 - Research Questions and Relevant Sections:

Theme	**Research Questions**	**Sections where addressed**
Digital Economy	1. *How do KS3 pupils and teachers understand the digital economy and broader digital world and how are the pupils understanding being shaped by the delivery of 2014 computing curriculum?*	*2.4.2, 3.2, 5.2, 6.2, 7.2*
Digital Literacy	**2.** *Do KS 3 pupils and their teachers feel that the 2014 computing curriculum is teaching pupils to be digitally literate?*	2.4.4, 3.3, 5.3, 6.3, 7.3
Computational Thinking	3. *What do KS3 pupils and teachers think computational thinking is and are pupils (and do pupils feel they are) learning how to think computationally or apply the principles of computational thinking through the 2014 computing curriculum?*	2.4.5, 3.4, 5.4, 6.3, 7.4

To conclude, this thesis has sought to better understand the impact of the 2014 English computing curriculum on young people. By using qualitative methods, this study has been able to allow young people's voices to contribute to a deeper understanding of computing education in England. Using the three core themes of computing education, this thesis has been able to explore the desired effects of the computing curriculum and what the delivery looks like on the ground. This thesis contributes greatly to an understanding of computing education in the UK, and across the world, as the community better seeks to understand the distance between the desired effects of policy decisions and what teaching computing to young people looks like in practice.

Chapter 9: Afterword

9.1 Afterword - A review of Recent literature

Before beginning, I am writing this in February of 2021; when I started this project there was no way I could have anticipated that the years of 2020 and 2021 would be defined by a global pandemic, which would mean (most relevantly for this thesis) that young people across the globe would be dependent on access to computers and the internet to access education in any form. Where video conferencing, which had previously seemed like an interesting idea for schools, has now become an essential tool for ensuring that young people are able to see their teachers. This, if nothing else has brought home that no matter how important computing education is, it is essential that young people have the digital literacy life skills to use the tools they need. During this time, using digital technology has become as essential (if not more essential) to the educational landscape as pen and paper. At the same time, it is clear that both young people and teachers can learn to deal with the new normal; that said, it will be a long time before we fully comprehend the consequences on those who have not been able to adapt to this new educational landscape.

While the original research for this PhD was conducted in 2016 with various versions of the literature review being completed around the same time. Computing education is a developing field and, since that point, many important papers have uncovered key insights about the field. Almost as importantly, a number of key organisations have released grey literature which has taken stock of the state of the computing education both in the UK and beyond. The purpose of this afterword is to highlight some valuable aspects of this literature and reflect on what this means in terms of this thesis.

The literature used for this afterword has been collected using a 3-step process;

1. **Academic Paper Selection**: Computing Education papers were selected for this afterword by looking at the publications from the last 4 years from three conferences: WIPSCE, ICER, and ITiCSE. These conferences were selected from a broader list a of computing education conferences (14 entries). Conferences which did not exclusively focus on the field of “computing education research” were eliminated. This resulted in a set of five conferences of which the three that were felt to have the most impact, the most international reach, and the most accessible archived material were selected. This process also involved taking onboard some recommendations from academics in the field regarding specific papers for consideration. Once the three conferences named above were selected, the archives since 2017 were considered. Papers were considered relevant based on references to the three key themes of this thesis: Digital Economy, Digital literacy and Computational thinking. Papers were also considered relevant if they had used qualitative research with young people. This process resulted in the selection of a total of 15 papers that were read and considered for this afterword.

2. **Selection of Key reports:** By the end of the Ph.D. process, it was clear that there had been an increase in grey literature in the areas of Computing Education. The researcher was aware of a number of these recent reports even before beginning to write this afterword. To confirm the selection of these reports, the research checked the ‘reports and policy’ section of the Computing at School web site (https://community.computingatschool.org.uk/resources/64/single) and attended relevant events that occurred at the end of this research period, including the “Digital Technologies in the Lives of Children and Young People" event hosted by the London School of Economics. Finally, generic searches were conducted using the key words for this thesis (Digital Economy, Digital literacy and Computing education) alongside

the words "young people" and "report". This process resulted in the identification of the five grey literature reports that have been used in this afterword.

3. **Recommendations from peers:** Finally, the research conducted discussion with a network of Computing Education researchers (linked through a Facebook group based on this topic). After a generic request for paper recommendations, a number of private conversations developed with other researchers active in computing education. These discussions (public and private) resulted in the consideration of a further six papers for this afterword.

Table 12 - literature selected for reference in this afterword.

Category	Title	Citation	Stage of Selection
Conference	*What do secondary school students associate with the digital world?*	(Brinda, Napierala and Behler, 2018)	Stage 2
Conference	*Features of Professional Self-determination and Professional Orientation of Young People in the Digital Economy*	(Dinner and Polovinko, 2018)	Stage 3
Report	*Report on Interviews with Experts on Digital Skills in Schools and on the Labour Market*	(Donoso et al., 2021)	Stage 1
Conference	*An International Study Piloting the MEasuring TeacheR Enacted Computing Curriculum (METRECC) Instrument*	(Falkner et al., 2019)	Stage 2
Conference	*From Theory Bias to Theory Dialogue*	(Kafai, Proctor and Lui, 2019)	Stage 2
Conference	*Computing Teachers' Perspectives on Threshold Concepts*	(Kallia and Sentance, 2017)	Stage 2
Report	*Youth and the Digital Economy: Exploring Youth Practices, Motivations, Skills,*	(Lombana-Bermudez et al.,	Stage 1

	Pathways, and Value Creation	2020)	
Conference	*Computing Education Theories*	(Malmi et al., 2019)	Stage 2
Academic Report	*Computing in the school curriculum: a survey of 100 teachers*	(Mee, 2020)	Stage 3
Report	*Skills for a Digital World*	(OECDa, 2016)	Stage 1
Report	*Policy Brief on the Future of Work- Skills for a Digital World*	(OECDb, 2016)	Stage 1
Report	*After the Reboot: Computing Education in UK Schools*	(Royal Society, 2017)	Stage 1
Conference	*A Periodic Table of Computing Education Learning Theories*	(Szabo et al., 2019)	Stage 3
Report	*Informatics Education in Europe: Are We All In The Same Boat?*	(CECE, 2017)	Stage 1
Report	*Education for a Connected World*	(UK Council for Internet Safety, 2020)	Stage 1

This initial search revealed 20 key papers and reports, but after reading, only 15 were determined to be suitably relevant to the study. This breaks down as 7 reports, 2 papers regarding the digital economy, 1 report by an academic regarding a survey of teachers, and 5 papers concerning the developing theory of computing education.

This literature focuses on three specific areas. The first section looks at the relationship of computing education and the digital economy; this section focuses on the importance placed on digital literacy, specifically in relationship to the young people's success. This starts by looking at how essential it is that young people are adequately informed about the digital economy to make responsible career choices (Dinner and Polovinko, 2018). This section also covers two of the grey literature reports, both published by the OECD (Organisation for Economic Co-operation and Development) as they look specifically at the impact of computing education on the Digital Economy.

The second section of this chapter will look at key grey literature, looking at the three of the five reports (which look most broadly at the state of computing education). Key amongst these is the Royal Society's "After the Reboot": a report which was written to update and reflect on the "Shut down or restart" report which had played a key role in the bringing about of the 2014 computing curriculum (Royal Society, 2012; Royal Society, 2017). This report is put alongside two further reports that look at computing education across Europe, putting what has been happening in the UK in the context of a wider range of countries: "Informatics Education in Europe: Are We All In The Same Boat?" (CECE, 2017) used quantitative data to look at computing education across Europe, whereas the "Report on Interviews with Experts on Digital Skills in Schools and on the Labour Market" used expert interviews to look at digital skills as taught in school and the labour market (Donoso et al, 2020).

In the final section, this chapter will look at the developing theory of practice for the field of computing education.

While none of the material here contradicts the findings of this thesis, it all seeks to add context and depth the material presented. In many cases, similar challenges are raised, and while on one hand, this reiterates the importance of this PhD, it is disappointing that teachers specifically are struggling with many of the same challenges that they had 5 years ago.

9.2 Digital Literacy and preparing for the Digital Economy and the Digital World

While the thesis itself tried to make a clear distinction between Digital Literacy and Digital Economy much of the more recent literature has brought these two themes together specifically looking at how digital literacy skills are key to being prepared for a future as part of the Digital Economy. In reviewing the recent literature, it has been hard to make clear distinctions between the three themes of this thesis: Digital Literacy, Digital Economy and Computational thinking.

This thesis looked at how the young people have little sense of what the digital economy might entail, specifically noting that young people had little sense of how the computing curriculum related to the world of work which they saw themselves entering in the future.

This sentiment is echoed by Dinner and Polovinko (2018, 335) who looked at how young people were being prepared for the "fourth industrial revolution", looking at the importance of "professional orientation and professional self-determination" as a "stage of professional choice in the process of the first job search" (Dinner and Polovinko, 2018, 336). Dinner and Polovinko reiterate the importance of "young people-friendly methods" of introducing young people to the potentials of the world of work, taking into account soft skills and competencies and also external factors (Dinner and Polovinko, 2018, 342). These findings are particularly interesting in relation to the findings of the qualitative approach taken for this thesis, as it demonstrates that experiences related by the young people in regard to the Digital Economy, are not giving them a sense of the importance or value of what they are learning. This is further explored by Brinda et al. (2018) who looked at what words high school students in Germany associate with the concept of the "Digital World", both with and without a focus on computer science (Brinda et al, 2018, 1). While they found that the most frequent words associated with "the digital world" were "computer, cell phone, and internet" (Brinda et al, 2018, 8), the authors' conclusion was that these associations had as much if not more to do with the media consumptions by the young people, echoed by the fact that (after these first three terms) the next most common terms were "television and social networks". This study was conducted in an area of Germany where there is not yet compulsory computing education (as we find in England), and it might be relevant to conduct a similar study in countries where this is the case. It does reflect that young people's understanding of the digital world is being significantly shaped by their experiences beyond the classroom as also found in this thesis. This highlights the need for compulsory education to develop a deeper and more comprehensive understanding of the digital world. However as highlighted in this thesis, this can be difficult as the 'digital world' and 'digital economy' are constantly developing. The literature section of this thesis (section 3.2) explored how the digital economy is affecting most areas of life, and a narrow understanding of the digital world could easily limit the extent to which young people value what they are learning through the computing curriculum.

This is reflected by the report by the OECD from 2016 "Skills for a Digital World" (OECDa 2016), which found that the digital economy was impacting almost all areas of life and that:

"Workers in the digital economy should be able to generate and process complex information; think systematically and critically; take decisions weighing different forms of evidence; ask meaningful questions about different subjects; be adaptable and flexible to new information; be creative; and be able to identify and solve real-world problems). These

requirements do not create a demand for new skills but rather increase the importance of some human competences that have been valuable for many centuries."

The report highlights the specific importance of digital literacy skills, skills that are key to "life-long learning" (OECDa 2016, 12). The report also asks: "The pervasiveness of digital technologies in today's lives has fed growing expectations on their benefits for education and raises questions as to the reasons why these benefits have not yet fully materialised" (OECDa 2016, 30). The report highlights findings that including ICT across the curriculum can be one of the most effective ways for young people to see the relevance of digital skills. From this thesis, it seems this is not yet happening in schools in England, but that many of the skills associated with ICT and digital literacy have been overshadowed by a focus on computer science-related concepts. These findings were further emphasised in a separate OECD report (OECDb 2016) which looked specifically at the Skills for a Digital World. This report also highlights that the Digital economy needs skills such as "socio-emotional skills to work collaboratively and flexibly" (OECDb, 2016, 1) - and reiterates the broad impact of digital technology: "The use of ICT in the workplace – affecting only a handful of occupations a few decades ago – is now required in all but two occupations in the United States: dishwashing and food cooking". Furthermore, going beyond the world of work, the digital world is changing "interaction between public and social services and business" (OECDb, 2016,1; UK Council for Internet Safety, 2020, 2). This again creates an interesting parallel to the statements from both teachers and young people in this thesis about needing "Digital life skills" beyond what is currently covered in the computing curriculum. The OECD's findings are that while education must ensure that all pupils have "basic ICT skills", as these are needed for almost all workplaces, they also find that in terms of specialist skills "Basic programming is no longer enough" (OECDb, 2016, 3). In light of these findings, in comparison to the data collected for this thesis (in the same year as these reports were published), the approach taken by the 2014 English Computing Curriculum meets neither of these needs: neither ensuring all young people have basic ICT (or digital literacy) skills or going beyond basic programming. However, this is also a big ask as this thesis has found since teaching even ‘basic programming’ to all young people can be a significant challenge.

Taking a less abstract approach, Lombana-Bermudez et al. (2020) have taken a much more detailed look at how young teens are already engaging in the Digital Economy in direct ways, often using social media to generate both actual capital and social capital (which can give them access to future capital). This report is of particular note as it looks at the consequences of young people moving from being ‘content consumers’ to ‘content creators’. They highlight a number of key findings, which are relevant when considered in the context of computing education.

There is a widening skills-based digital divide that is not superficially apparent, where those who are successfully engaging have a high level of skills and access to resources, plus the knowledge that many young people do not have access to (Lombana-Bermudez et al. 2020, 12). Young people feel they have knowledge of how to interact online but may be missing the bigger picture. Young people are not always fully aware of the impact of sharing their data. While they are aware of ‘digital reputation’ and not giving away personal information, they are less aware of how personal data plays a key role in the business models of social media companies (Lombana-Bermudez et al. 2020, 13).

These findings suggest that there is a clear impetus to address the gaps highlighted in this thesis. Moreover, it again highlights that the lack of coverage of ‘social media’ beyond basic e-safety in the English computing curriculum is a significant oversight.

The literature covered in this section shows that in terms of preparing young people for the digital economy and the digital world, there continue to be key challenges. What is also clear is that, in many ways, the educational context is still in an early stage of understanding how to meet these challenges. The next sections will look at a wide range of recent literature which looks more specifically at new literature with regards to Computing Education.

In table 8 in section 7.2.5, this thesis stated:

One of the largest challenges for the curriculum is that, while it aims to prepare young people for the digital economy and digital world, there is little sense of what this might be. The curriculum may be preparing young people for a narrowly defined digital economy, but they are not necessarily being prepared for a broader digital world. Furthermore, there is a question about how young people's understanding of the digital economy is being impacted by the curriculum – the experience of the young people and the teachers seems to be that their understanding of the digital world and digital economy is not being developed substantially by the computing curriculum.

The new literature has echoed these findings of the thesis. However, in addition, the literature has provided a significant theoretical and research base from which to consider the importance of education about the digital economy. Whereas the thesis highlighted that the computing curriculum existed in the context of the digital economy and that young people did not feel they were being prepared for that future world of work, the literature reviewed in this section demonstrates that by not preparing young people for the digital economy, there could be significant consequences both in terms of career choice (for the young people), but also in terms of being exposed to risks and harms they may not even be aware of.

9.3 Progress in the Grey Literature, Calling for more Digital Literacy.

Since the writing collection of the data for this thesis, a number of national and international reports have taken stock of the computing education landscape. This next section looks at three of these, and while there may be others, these specific reports add depth and context to the findings of this thesis. Most obviously the Royal Society "After the Reboot" (2017) followed on from the previous report from "Shut down or restart" (2012) and looked at the impact of the 2014 computing curriculum. Where this thesis took a qualitative approach specifically focused on young people's experiences, this contrasts the method taken by “After the Reboot”, which used teacher surveys to investigate similar questions: “To understand how computing is being taught in the UK, we surveyed 341 primary school teachers and 604 secondary school teachers with a responsibility for computing education over a two-month period. The purpose of the survey was to understand the impact of recent policy changes on computing education.” (Royal Society, 2017, 19).

As well as looking at the report from the Royal Society, this section will also look at computing on an international level, mostly focusing on quantitative and publicly accessible data. The report “Informatics Education in Europe: Are We All In The Same Boat?” (CECE, 2017), examined computing (also called Informatics) education across Europe, (including the nations of the UK); through this comparison, it is possible to understand where the English Computing Curriculum is succeeding and where it is falling short. For example, highlighting that across the UK there is one of the most comprehensive compulsory curriculums across primary and secondary schools, but this is partially undermined in England by a lack of inclusion of digital literacy and a lack of requirement for teachers to be trained in computer science (CECE, 2017, 243).

Staying on an international level, the “Report on Interviews with Experts on Digital Skills in Schools and on the Labour Market” report from July 2020 (Donoso et al, 2020) interviewed experts on digital skills in school around the delivery of skills for the labour market. While the next section of this afterword looks at the recent literature around the digital economy and digital literacy, this report is placed here as the focus of the interviews is on the role of (computing) education to deliver these skills.

All three of these reports are very detailed and of significant value to the field of computing education. For the context of this thesis and afterword, this section can only briefly discuss the most relevant findings of these reports in the context of the findings of this thesis.

Perhaps one of the most relevant takeaways from “After the Reboot” is that there is a call for more research in the field of Computing Education (Royal Society, 2017, 97), something that this thesis has hoped to help address.

The reports echoes many of the findings of this thesis, reinforcing, for example, the need for (and the current lack of) teachers with appropriate background and training in computing (Royal Society, 2017, 85). Similarly, the “Report on Interviews with Experts on Digital Skills in Schools and on the Labour Market” report also highlights that not only do teachers need to be trained but need to stay up-to-date with “technological innovations and trends concerning young people's digital usage” (Donoso et al, 2020, 67). What is also clear is that, based on the time allocated to computing and the training required of computing teachers across Europe, computing is not considered to be on par with other sciences and STEM subjects (CECE, 2017, 22). In the nations of the United Kingdom, for example, teachers can teach computing (Informatics) with little or no specialist training in the field: “any teacher is allowed to teach Informatics without any extra training” (CECE, 2017, 21). This highlights that on one hand, there is a need for more teachers of computing, while on the other hand, those teachers need a high level of training and expertise. In many areas across Europe, there is a lack of well-qualified and enthusiastic teachers (CECE, 2017, 19). In England, teachers specifically feel they have been placed in a difficult position as they feel “the Government has changed the subject they teach without providing them with sufficient support to teach it effectively” (Royal Society,2017, 33).

In terms of content that is being delivered, the UK has the most comprehensive delivery of compulsory computing education across Europe (CECE, 2017, 14). All three reports comment on the need for Digital literacy alongside computing. Based on the data and expert views presented in this thesis, digital literacy and computing are best delivered as separate subjects (neither able to replace the other), which are both equally important to young people. However, “there are rarely stand-alone curricula for teacher training in Digital Literacy. Thus, there is the danger that the subject is taught by teachers who do not have the appropriate subject-matter knowledge”. In other words, the teachers are not getting specific and standalone training in digital literacy (CECE, 2017, 5).

What is also clear is that (as highlighted in this thesis) Digital literacy must go beyond young people being digitally skilled and should include a range of cognitive and social skills: “Besides technical skills, experts attached great importance to non-technical skills such as critical-thinking and information processing skills, ethical use of digital technologies, protecting personal data and privacy and managing one’s digital identity” (Donoso et a. 2020, 22). There is also a concern that, where digital skills are referenced in curricula, there is not always clear guidance on what should be taught or how (Donoso et al. 2020, 29). This seems particularly relevant where digital skills are to be taught across the curriculum (beyond computing), but other subject teachers are given no training or guidance for what this would look like. The initial calls for curriculum reform highlighted the need for a focus on digital literacy, and there remain concerns about the lack of emphasis on areas such as Information technology (as a distinct qualification to computer science) (Royal Society, 2017, 12). The evidence gathered by the Royal Society suggests that teachers and young people in England regard computing as “difficult” and only suitable for the most highly achieving young people (something reflected in the findings of this thesis) (Royal Society, 2017, 33). This could have the impact of effectively limiting the take-up generally (and specifically in terms of the

GCSE and A level qualification) of computer science, to those who are assumed to be most highly achieving. Pressure is additionally put on the subject by only being given a limited amount of time in school timetables, and a lack of qualified teaching staff (Royal Society, 2017, 25).

As has been previously stated there is a strong argument and call that digital education includes both technical and non-technical aspects, as young people will need both of these to engage in modern society (Donoso, et al. 2020, 67). Alongside the need for clear guidance and training, however, is the need for investment in equipment (something that was also raised in section 7.6 of this thesis), as there continue to be young people with limited access to digital equipment and technology (Donoso et al, 2020, 66).

There is no doubt that computing education is highly important and relevant to young people today, and in many ways, the UK is leading the way by providing compulsory computing education in both primary and secondary schools. The introduction of the 2014 English computing curriculum should be celebrated as a key milestone for computing and informatics education across Europe and the world. But, as Donoso et al. highlight in their findings, curricula must be in tune with the realities of the young people's lives:

"The experts we interviewed felt that, in respect to the teaching of digital skills, school curricula often lag behind the developments in the private economic sector and society. Thus, the experiences children actually gather as regards digital technology as part of their daily lives are only insufficiently covered by school curricula. Additionally, especially the labour market experts interviewed felt that the digital skills taught at school do not necessarily match the skills required for being successful on the labour market. Hence, it is necessary to update the national school curricula regularly in order to keep track with

accelerated technical advance which continue to change everyday life" (Donoso et al, 2020, 66).

With that in mind, and an ever-increasing (if still limited) research base regarding computing education, there may be a need to revisit the computing curriculum, with a deeper understanding of its impacts.

Table 9 in sections 7.3.5 of this thesis concluded:
The young people did not seem to feel they were being taught to be digitally literate, both in line with the aims of the National Curriculum and the broader three-fold definition of digital literacy. If the young people are to learn to be 'digitally literate' through the computing curriculum, teachers will need more time to deliver the skills of digitally literacy, but also the term 'digital literacy' needs to be updated and re-examined to reflect better the world in which the young people live.

Reflecting on this conclusion, in light of these more recent reports, the need for digital literacy and digital skills seems ever-present, and while computing and informatics are clearly important and face many challenges, at this point in time it may be better to focus on ensuring that young people do feel they are becoming digitally literate and gaining the appropriate digital skills. Teachers need appropriate training in digital literacy (as well as in the other areas of computing), and while there are ongoing initiatives to ensure that teachers are better prepared to teach computing (through government-funded centres such as the NCCE – National Centre of Computing Education), it is not just the technical skills that are the problem, but finding a way of including digital literacy in a comprehensive, potentially cross-curricular and sustainable way.

9.4 Building a (new) theoretical understanding of Computing Education

In recent years there have been a number of key academic papers demonstrating the maturing of Computing Education as an area of research. For this afterword, papers have been reviewed which can help contextualise the ongoing field as relating to the findings in this thesis. Many of these have focused on developing the theoretical context of computing education.

Mee's 2020 survey of 100 KS3 and GCSE computing teachers reinforces many of the key findings of this thesis, specifically that teachers continue to find that the curriculum is dominated by teaching programming, and while teachers value programming, they also feel it takes up too much time (Mee, 2020, 4). There continues to be a lack of breadth and balance in computing (Mee, 2020, 4), resulting in a subject that remains "inaccessible to most" (Mee, 2020, 4). This work has mostly focused on UK schools, but as has been highlighted in previous sections it is useful as a starting point to understand computing on an international level.

Highlighting the need to better understand computing education as it is delivered across the world, Falkner et al (2019) worked with a wide range of academics from around the world to develop a tool for looking at the differences between the prescribed curricula and how they are enacted. This tool is of particularly use (as it develops) to be able to compare the difference between different countries' enactment of computing curricula (Falkner et al, 2019, 137). They particularly note that teachers remain the gatekeepers of computing, and their interpretation of the relevant curriculum is paramount (Falkner, 2019, 137). This may explain some of the focus areas such as programming. Programming can dominate computing classes, which may not be ideal, but it highlights that it is necessary to better understand how to teach programming more effectively, and which areas pupils find most difficult.

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, 23). Understanding the threshold concepts can be key 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, 23).

Broadening out to the teaching of computational thinking more generally, this thesis has looked at a wide range of understandings of the term ‘computational thinking’ as the term has continued to be contested across the field. There is a remaining research question of how important these different understandings of the terms might be.

In the area of Computational Thinking, Kafai et al (2019) start to look at how the interpretation and underpinning theory help the delivery of computational thinking:

“The increased interest in promoting CS education for all has been coalescing around the idea of ‘computational thinking.’ Several framings for promoting computational thinking in K-12 education have been proposed by practitioners and researchers that each place different emphases on either (1) skill and competence building, (2) creative expression and participation, or (3) social justice and ethics.” (Kafai et al, 2019, 101)

What they observe of all of these different framings of ‘computational thinking’ (in contrast to how computational thinking has been taught in previous generations) is that:

“One striking commonality is that the learning of computational thinking within each of these three framings is often situated in the context of designing applications such as instructional software or games rather than learning code for its own sake.” (Kafai et al, 2019, 104)

They highlight that the main difference of these different framings is how they balance basic programming vs how the [programming] skill can be used "for personal/social enrichment and to address issues within the world-at-large" (Kafai et al, 2019, 104). They propose that research in the field of computational thinking should be more inclusive and make room for various framings, focusing rather on an interdisciplinary approach to computational thinking in particular (Kafai et al 2019, 107).

This multidisciplinary approach is reflected in work that looks at establishing learning theories that can be used in computing science education (Szabo et al, 2019, 91). Since the completion of this thesis, one of the key growths in Computing Education research has been the examining and development of theory to underpin the teaching of computing (Malmi et al, 2019; Zabo et al, 2019).

It is critical to establish the underpinning theory for computing education and how existing theories are applied to computing education, as it will enhance the teaching and scholarship in the area of computing (Szabo et al, 2019, 105). A number of learning theories were found being applied to computing, with several influential papers within the computing education field (Szabo et al, 2019, 104).

On the research side, there is also a range of research methods being used in Computing Education Research (CER) and there are suggestions that there is a need to establish domain-specific knowledge for computing education research (Malmi et al, 2019, 194):

"There is a wealth of theories used in CER, and a wealth of ways in which theories can be used in the field. As a young research discipline, computing education borrows theories and methodologies from the social sciences, which are themselves not homogeneous when it comes to ways of conceptualizing and using theories" (Malmi et al, 2019, 188).

Whilst this section has considered just a small sample of the papers published in recent years with regards to computing education, these papers demonstrate how a next key challenge for computing education is better understanding itself not just as an academic discipline but also as an area of academic research. What this thesis does most in terms of a theoretical framing of computing education is to contextualise the framing of the digital economy, while also using a methodology that looks at the experiences of young people, as they experience computing education, rather than as it is interpreted by teachers.

In table 10 in sections 7.4.5 of this thesis states:
The aims of the computing curriculum indicate that the young people should be learning to use computational concepts to analyse and solve problems and having the practice of writing computer programs to solve problems. The central challenge encountered by the teachers and young people is in ensuring the young people have enough practice and knowledge of programming to be able to write programs that solve problems.

While the curriculum would indicate that young people should be learning ‘the programming’ approach to computational thinking, the understanding of the teachers and young people seems to best align with the ‘general problem solving approach’ – teachers and young people need a consistent understanding of the concept ‘computational thinking’.

Programming is continuing to dominate English computing lessons, but the development of the field of computing education research may be able to add insight on how to make this teaching more efficient. There is a question about what young people should be learning and how, for example when it comes to the underlying theories and concepts of computing and computational thinking. These are not questions that can be answered by looking at the needs of the digital economy, or the skills that young people need to function in a digital world. Computational thinking is a way of understanding the world and being able to solve problems in it. It seems that while many important papers regarding computing education research may not directly or immediately impact the delivery of computing in classrooms, the impact is slowly filtering through to new training courses as well as teacher-facing resources such as Research Bytes [4], Pedagogy Quick Reads [5] and the magazine Hello World [6]. Importantly, such research papers build a more mature field of research which, on the whole, is better placed to answer the questions and investigate the key challenges of computing education.

9.5 A Final Conclusion.

Computing Education is a quickly developing field. Computing is becoming a more and more important part of the education landscape, and while it is clear that young people need to have comprehensive digital literacy skills to be able to participate in society, they equally need to have the knowledge and understanding of the technology that surrounds them to be able to make informed choices, whether about what services they use, or what career they want to pursue in the future.

This thesis has critically examined the impact of the 2014 English Computing Curriculum on young people in KS3, using the innovative approach of speaking to young people themselves about their experiences. Looking at the literature from the years since this data was collected, it is clear that many of the same concerns and challenges remain. Across the world, countries are attempting to get the balance correct between teaching computer science and something that more closely resembles digital literacy. These are difficult choices and currently the answers are still unclear. This thesis presents one set of findings showing that, at least in these early years of computing education in England, the curriculum is not meeting the needs of all young people. What should not be taken lightly is that England was

[4] https://teachcomputing.org/pedagogy
[5] https://teachcomputing.org/pedagogy
[6] https://helloworld.raspberrypi.org/

ahead of many other countries in introducing a comprehensive computing curriculum for young people in primary and secondary schools and this ambition should be applauded even if there remain challenges that need to be addressed.

In the context of this new literature, it seems clear that there is a need to re-examine how digital literacy is taught to young people. What also remains a challenge is ensuring that teachers have adequate information about digital technology to provide accurate information to young people, and ensuring that teachers have an appropriate specialist background and/or training to teach computer science to a high level.

As the field of computing education is developing, building a research and theory base along with related tools will, over time, bear fruit to be able to fully understand the computing education landscape and picture across the world. There is a need for a richer research landscape to underpin the practice in delivery. Computing is in its infancy when compared to other subjects such as maths or science; hence there should not be an expectation that difficult questions about what should be taught and how can be answered quickly. Having said that, young people are experiencing computing every day, being introduced to programming for the first time, and possible learning to apply computational thinking for themselves. While it may feel there is a need to have patience in developing an appropriate research-based approach to teaching computing in schools, the decisions that are made have an immediate impact on current cohorts of students.

This thesis has argued that, in a field where those impacted are young people, it is possible (if not essential) to place those young people at the heart of the research; in our research, there should be a willingness to speak to them directly about their experiences and ask them for their insights and understandings.

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Appendices

Appendix I

Information and Consent form for teachers, Pupils and Parents

Research study:

Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3

Participant Information Sheet (Teacher)

Date: 19th of April 2016

Version: 3.1

Studying the Key Stage Three computing curriculum

This study will be looking at how teaching computing impacts on pupils' attitudes and beliefs about working with computers in the future.

The purpose of this study is to explore the impact that the Key Stage 3 computing curriculum is having on students' and teachers' attitudes toward enterprise, entrepreneurship and working with computers in the future. The research will be conducted through a mixture of observations and interviews.

Why have you been asked to participate?

It is important that this study takes place in authentic classroom environments within the course of a typical school day. I am therefore seeking the support of teachers and schools to allow me to observe their teaching and also conduct interviews with them and their pupils.

Do you have to take part?

No, taking part in this study is entirely voluntary. Your relationship with your school, the researcher or Lancaster university will not be impacted by choosing not to take part in this study.

What will you have to do if you take part?

If you, your school, and the parents of the children agree to take part in the study, I will spend time observing you teach a number of typical computing lessons covering the normal material that you are delivering at the time. I will also conduct a single semi-structured interview with you, any other teachers who teach computing at your school as well as your head teacher/head of department. During the observation I will ask for a small group of young people to volunteer to take part in a group interview.

This research is not intended to evaluate you as a teacher, your ability to teach computing, or any specific way of teaching computing. Rather, this study is looking at the impact of teaching computing on students' attitudes about the digital economy.

During the study I will be taking notes while making observations. I will also be taking photographs and short video recordings of parts of the computing lessons. These short videos will supplement my notes, they will be a way of me capturing the broader atmosphere of the classroom. Although I may video parts of the lesson, I will not be filming the whole lesson. All interviews will be audio recorded and then transcribed. As these will be semi-structured interviews, they may feel more like a conversation. Any photographs and recordings may be used to supplement the notes and observations I make. Audio recordings of interviews used as part of the final analysis for the Phd thesis will be fully transcribed. Where photographs are used in my thesis or further publication every effort will be made to ensure that no individuals are identifiable, for example all faces and school logos or names will be distorted.

How will your data be stored and protected?

All data collected in this study will be kept on secure encrypted and password protected digital storage. All videos, photographic and audio data will be transferred from any recording device to an encrypted password protected hard drive at the end of each day's observations, and then deleted from the recording device.

There are two forms of data which will be treated as described below. These are **non-anonymised data** and **anonymised data**.

Non-anonymised data (including video content, photographs and data linked to participant names) will be stored until the end of my Phd which should be approximately October 2017, although potentially could take longer. This enables me to analyze the data and produce anonymised forms of it. Only my direct academic supervisors and I will have direct access to this data.

Anonymised data (in which participant names or other identifying attributes have been removed) will be stored for a minimum of 10 years and may be stored indefinitely. For example, audio data is anonymised by transcribing the events in the recording and using pseudonyms to refer to individual people. It is requirement of my funding from the Research Council that anonymised data is stored for this length of time. What I mean by transcription is that what people have said during the recording is written down; make something like script of what has been said. This is sometime done by computer software or in other cases done by a person

How will your data be used?

Anonymised data (including all observed classroom activity, and interview transcriptions) will be used for the completion of my Ph.D. thesis and corresponding academic publications such as papers or conference presentations.

Although I may use direct quotes either from interviews or observations in my thesis or other publications these will be anonymised, before appearing. As previously stated, if I use any photographs or videos in my thesis or other publication, every effort will be made to ensure that individuals are not identifiable.

Non-anonymised data will never be used in this way and will only be used to generate anonymised data.

What are the benefits and risks of taking part?

By taking part in the research you are helping the investigation of the impact of the KS3 computing curriculum. This research will be exploring how the policy intentions which motivate the development of UK curriculum are then delivered through activities in the classroom and the impact this then has on pupils' attitudes towards enterprise, entrepreneurship and the digital economy. The final thesis written from this project will include policy recommendations about how the computing curriculum could better take its impact on young people into consideration.

You and your school may benefit from being involved in this project because you will have access to current research regarding teaching computing to young people. I have spent many months researching and understanding the curriculum, the policy context of it and the priorities which will go into evaluating it. I will be able to discuss this context with you throughout the study.

The risks of participating in this study are minimal. Your identity will remain confidential and will be anonymised on all project documentation and results, as described above.

What if you change your mind?

You can withdraw from the study at any time. If you withdraw within two weeks from the end of the fieldwork phase of the study (approximately October 1st, 2017), all data that relates exclusively to you will be destroyed (both anonymised and non-anonymised forms). If you withdraw after the two-week period, anonymised data may be used as outlined above. If I destroy data as a result of your withdrawal, note that data such as in-class videos, in which you may appear peripherally, will still be retained. Please Note, that if you withdraw *during* the study it is possible that I may not carry out any further sessions at your school, depending on the feasibility of continuing to work only with the other teachers at your school; this will not affect your relationship with your school or Lancaster University.

Further information

Individuals involved in this study.

Researcher/ Ph.D. Candidate: Benjamin Wohl, HighWire CDT, LICA, Lancaster University, LA1 4WA, b.wohl@lancaster.ac.uk

First Supervisor: DR Lynne Blair, School of Computing and Communications, Lancaster University, LA1 4WA l.blair@lancaster.ac.uk | 01524 510360

Second Supervisor: Professor Martyn Evans, Manchester School of Art, Manchester Metropolitan University, Cavendish St, Manchester, M15 6BG Martyn.evans@mmu.ac.uk | 0161 247 1292

Observations and interviews carried out in your school will only be carried out by Benjamin Wohl who is DBS checked and will bring his DBS certificate with him to all observations. If you wish to carry out an additional DBS check for your school specifically please let me know.

If you have any questions about this project, please contact either Darren McCabe or Martyn Evans.

Concerns or complaints

If you have any concerns or complaints, please contact:

Professor Gordon Blair
Head of Department, HighWire

G.blair@lancaster.ac.uk 01524 510303

This study has been reviewed and approved by Lancaster University's Research Ethics Committee.

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Research study:

Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3

Participant Information Sheet (Pupil)

Date: 19th of April 2016

Version: 3.1

Studying the Key Stage Three computing curriculum

The purpose of this study is to explore the impact that teaching computing is having on students and teachers. Specifically, I am interested in on how it may affect your attitudes towards working with computers in the future, using computers in employment or even starting your own business.

Do you have to participate?

Taking part in this study is entirely your choice Your relationship with your school or your teacher will not be impacted by deciding not to take part in the activities associated with this study. If you choose not take part in this study suitable alternative arrangements will be made this may mean either I will work with another class in your school where you are not present, or you may be given alternative work by your teachers.

You and your peers will be asked if you would like to take part in a group interview. Participation in the group interview is also entirely up to you.

What will this study involve?

I will be spending a number of days in your classroom to observe your ordinary computing/ICT lessons.

If you are interested, you will have the chance take part in a group interview. The group interview will cover your views about computing, your perception of what you are learning in the computing sessions, and how you think you will use computing in the future. These group interviews will be audio recorded. These interviews will be semi-structured meaning they may feel more like a conversation or discussion rather than strictly answering a series of questions. The audio recordings I make during these group interviews will be transcribed. Transcription means that what people have said during the recording is written down, make something like script of what has been said. This is sometime done by computer software or in other cases done by a person

During the study I will be taking notes while making observations. I will also be taking photographs and short video recordings of the computing lessons. These short videos and photographs will be used to supplement my notes (help me remember what occurred) and give me a more accurate record of the general classroom atmosphere. I may use some these photographs only in my thesis or other publication. I will only use photographs in the publication themselves and only where it is not possible to identify individuals.

All audio recordings, which are used as part of my final analysis, will be transcribed.

How will my data be stored and protected?

All data collected in this study will be kept on secure encrypted and password protected digital storage. There are two forms of data that will be treated as described below. These are **non-anonymised data** and **anonymised data**.

Non-anonymised data (including video content, photographs and data linked to participant names) will be stored until the end of my Ph.D. that should be approximately October 2017.

Anonymised data (in which your names or other identifying attributes have been removed) will be stored for a minimum of 10 years.

How will data about you be used?

There are two types of information I will use for this study. Anonymised data is information which cannot be linked back to you specifically, this could be because I have summarized what you have said or used a different name.

Non-anonymised data is information which could linked back to you, for example because it a picture of you, or information that uses your name.

Anonymised data will be used for the completion of my Ph.D. thesis and corresponding academic papers. To explain, when I am writing up the results of my research, it will not be possible for someone to read it and know what you said.

Non-anonymised data will never be used in this way and will only be used to generate anonymised data. Which means, although I may write down or record what you say, or take pictures of your work, these will only be used to help me make notes, or to make create information which cannot be linked back to you.

What if you change your mind?

Should you wish to withdraw from the study, you many do so at any time. If you withdraw from the study within two weeks from the end of the fieldwork phase of the study (approximately October 1st, 2017), all data that relates exclusively to you will be destroyed. If I destroy data as a result of your withdrawal, note that data such as in-class videos, in which you may appear peripherally, will still be retained.

Further information

Individuals involved in this study.

Ph.D. Candidate: Benjamin Wohl, HighWire CDT, LICA, Lancaster University, LA1 4WA, b.wohl@lancaster.ac.uk

First Supervisor: Professor Darren McCabe, Organization Work and Technology Lancaster University Management School, Lancaster University, LA1 4WA d.mccabe@lancaster.ac.uk | 01524 510950

Second Supervisor: Professor Martyn Evans, Manchester School of Art, Manchester Metropolitan University, Cavendish St, Manchester, M15 6BG Martyn.evans@mmu.ac.uk | 0161 247 1292

Observation sessions carried out in your school will only be carried out by Benjamin Wohl, who has A DBS check and has been approved by your school to carry out this work.

If you have any questions about this project, please feel free to discuss these with your teacher or with me.

This study has been reviewed and approved by Lancaster University's Research Ethics Committee.

Research study:

Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3

Participant Information Sheet (Parent)

Date: 19th of April 2016

Version: 3.1

Studying the Key Stage Three computing curriculum

The purpose of this study is to explore the impact that the Key Stage 3 computing curriculum is having on students' and teachers' attitudes toward enterprise, entrepreneurship and working with computers in the future. The research will be conducted through a mixture of observations and interviews

Why has your child been asked to participate?

It is important that this study takes place in an authentic classroom environment within the course of a typical school day. I am therefore seeking the support of schools, parents and pupils to allow me to observe lessons and also conduct interviews with both pupils and teachers.

Does your child have to take part?

Taking part in this study is entirely voluntary. Your and your child's relationship with your school or Lancaster University will not be impacted by choosing not to take part in the study. If you choose for your child not take part in this study either suitable alternative activities will be arranged for your child while the researcher is observing the lessons, or the researcher may only make observation while your child is not present. I will ensure that your child's education is not negatively impacted as a result of this study.

What will your child have to do if they take part?

If you, your child, and your child's teacher and school agree to take part in the study I will spend a number of days in your child's computing/ICT lessons while they cover the normal material that would be delivered at the time. During the observation of lessons, I will ask for a small group of young people to volunteer to take part in a group interview. The group interview will only take place with the consent of your child's teacher and will cover your child's views on computing, their perception of the value of the what they are learning in the computing sessions, and how they think they will use computing in the future.

This research is not intended to evaluate your child's teacher or your child's ability working with computers, or any specific way of teaching computing. Rather, this study is looking at the impact of teaching computing on student's attitudes.

During the study I will be taking notes while making observations. I will also be taking photographs and short video recordings of the computing lessons. All interviews will be audio recorded. These photographs and recordings will be used to supplement the notes and observations I make. All audio will be transcribed and used as part of the final analysis for the Phd thesis. Transcription means that what people have said during the recording is written down, make something like a script of what has been said. This is sometimes done by computer software or in other cases done by a person.

How will your data be stored and protected?

All data collected in this study will be kept on secure encrypted and password protected digital storage. All video, photographic and audio data will be transferred from any recording device to an encrypted password protected hard drive at the end of each day's observations, and then deleted from the recording device. There are two forms of data which will be treated as described below. These are **non-anonymised data** and **anonymised data**.

Non-anonymised data (including video content, photographs and data linked to participant names) will be stored until the end of my Ph.D., which should be approximately October 2017 although this potentially could take longer. This enables me to analyze the data and produce anonymised forms of it. Only my direct academic supervisors and I will have direct access to this data.

Anonymised data (in which participant names or other identifying attributes have been removed) will be stored for a minimum of 10 years. Audio recording, for example, is anonymised by transcribing the events in the video and using pseudonyms to refer to particular people in those events. It is requirement of my funding from the Research Council that anonymised data is stored for this length of time.

How will data about your child be used?

Anonymised data (including all observed classroom activity, and interview transcriptions) will be used for the completion of my Ph.D. thesis and corresponding academic papers.

Non-anonymised data will never be used in this way and will only be used to generate anonymised data.

What are the benefits and risks of taking part?

By taking part in the research your child will be helping the investigation of the impact of the KS3 computing curriculum.

Your child's school will benefit from being involved in this project because they will have access to current research regarding teaching computing to young people. I have spent many months researching and understanding the computing curriculum, the policy context of it and the priorities, which will go into evaluating it. I will be able to discuss this context with your school throughout the study, and should you have any questions regarding this area please don't hesitate to contact me. At the completion of the project I will produce a summary of research, which I will distribute to the schools, parents and pupils have taken part in the project.

The risks of participating in these studies are minimal. Your child's identity will remain confidential and will be anonymised on all project documentation and results, as described above.

What if you change my mind?

You can withdraw your child from the study at any time. If you withdraw your child within two weeks from the end of the fieldwork phase of the study (approximately October 1st, 2017), all data that relates exclusively to your child will be destroyed (both anonymised and non-anonymised forms). If you withdraw your child after the two-week period, anonymised data may be used as outlined above. If we destroy data as a result of your withdrawal, note that data such as in-class videos, in which your child may appear peripherally, will still be retained. Note that if your child withdraws *during* the study, I may not carry out any further sessions with your child's class; this will not affect your relationship with your school or with Lancaster University.

Further information

Individuals involved in this study.

Ph.D. Candidate: Benjamin Wohl, HighWire CDT, LICA, Lancaster University, LA1 4WA, b.wohl@lancaster.ac.uk

First Supervisor: DR Lynne Blair, School of Computing and Communications, Lancaster University, LA1 4WA l.blair@lancaster.ac.uk | 01524 510360

Second Supervisor: Professor Martyn Evans, Manchester School of Art, Manchester Metropolitan University, Cavendish St, Manchester, M15 6BG Martyn.evans@mmu.ac.uk | 0161 247 1292

Observations and Sessions carried out in your school will only be carries out by Benjamin Wohl who is DBS checked and will being his DBS certificate with him to all observations. A copy of Benjamin's DBS certificate will be held by the school should you wish to see it.

If you have any questions about this project, please contact either Darren McCabe or Martyn Evans.

Concerns or complaints

If you have any concerns or complaints, please contact:

Professor Gordon Blair
Head of Department, HighWire

G.blair@lancaster.ac.uk 01524 510303

This study has been reviewed and approved by Lancaster University Research Ethics Committee.

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Research study: Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3

Teacher Consent Form

Please tick each relevant box

❑ I confirm that I have read and understood the Participant Information for this study.

❑ I have had the opportunity to consider the information, ask questions about the research and have had these answered satisfactorily.

❑ I agree to take part in the research and understand that my participation is voluntary.

❑ I understand that I can withdraw from the study at any time, and that if I withdraw within two weeks from the end of the fieldwork phase of the study (approximately October 1st 2017), all data that relates exclusively to me will be destroyed (both anonymised and non-anonymised forms). If I withdraw after the two-week anonymised data will be retained.

❑ I understand that data collected during the course of this study will be stored as described in the participant information sheet.

❑ I agree that anonymised quotations can be used in any publications that arise from this study.

❑ I agree to be videoed as part of the data collection activities for this study.

❑ I agree to be photographed as part of the data collection activities for this

study

❑ I agree to be interviewed as part of this study.

❑ I agree for any interviews, which are conducted with me to be videoed for data collection purposes.

Date:
Name of participant: Participant's Signature:

Research study: Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3
Please tick each relevant box

Parent Consent Form

❑ I confirm that I have read and understood the Participant Information for this study.

❑ I have had the opportunity to consider the information, ask questions about the research and have had these answered satisfactorily.

❑ I agree for my child to take part in the research and understand that my child's participation is voluntary.

❑ I understand that I can withdraw my child from the study at any time, and that if I withdraw my child within two weeks from the end of the fieldwork phase of the study (approximately October 1st 2017), all data that relates exclusively to my child will be destroyed (both anonymised and non-anonymised forms). If I withdraw after the two-week anonymised data will be retained.

❑ I understand that data collected during the course of this study will be stored as described in the participant information sheet.

❑ I agree that anonymised quotations from my child can be used in any publications that arise from the study.

❑ I agree for my child to be photographed as part of the data collection activities for this study.

❑ I agree for my child to be videoed as part of the data collection activities for this study.

❑ I agree that should my child wish to volunteer he/she may take part in a group interview pertaining to this study.

❑ I agree for any group interview my child takes part in to be videoed for data collection purposes.

Name of participant (child): Date:

Name of parent/guardian: Signature of parent/guardian:

Research study: Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3

Agreement to take part (in class observation)

Your school is working with Lancaster University to study the impact of the computing curriculum.

Please sign at the bottom of the sheet if you agree that:

❑ I have had a chance to ask the researcher about this study

❑ I have had a chance to discuss this research both with my parents and with my teacher.

❑ If I do not want to take part, I understand that I do not have to. qI agree to allow a researcher to observe my computing/ICT classes

My Name _______________ Date___________________

Research study: Preparing young people for the digital economy:
How the English computing curriculum fosters enterprise and entrepreneurship at Key Stage 3

Agreement to take part (Group Interview)

Your school is working with Lancaster University to study the impact of the computing curriculum at Key Stage 3. You have volunteered to take part in a group interview. Please read the following statements and sign at the bottom of the sheet if you agree that:

❑ I have had a chance to ask the researcher and my teacher about the study.

❑ I have had a chance to discuss this research both with my parents and

with my teacher, including topics that will be covered in the interview.

❑ If I do not want to take part, I understand that I do not have to.

❑ I volunteered to take part in a group interviews regarding computing.

❑ I agree to be audio recorded during the group interview.

❑ My views, as discussed in the interview could be used as anonymised quotes in the final research.

❑ I have had a chance to read and discus the topics to be covered in this group interview, prior to the interview itself.

My Name _______________ Date ___________________

Appendix II
Expert Interview Information and Consent Form

Research study:

Preparing young people for the digital economy:
The impact of the English computing curriculum as delivered at Key Stage 3.

Participant Information Sheet (Expert Interview)

Date: 01st of November 2018

Studying the Key Stage Three computing curriculum

This study will be looking at how teaching computing impacts on pupils' attitudes and beliefs about working with computers in the future.

The purpose of this study is to explore the impact that the Key Stage 3 computing curriculum is having on students' and teachers' attitudes working with computers in the future. The research has been conducted through a mixture of observations and interviews.

Why have you been asked to participate?

The nature of this sort of research is that it can only be conducted with a limited number of participants. To better understand how the research findings could be applied to other studies I have arranged to speak to a number of Experts in the field of computing education (such as you). I have contacted you either because of your involvement in one the many originations across the UK involved in computing education (such as Computing at School) or because your current or past job role may give you insight into how well my data reflects how the computing curriculum is delivered across the UK.

Do you have to take part?

No, taking part in this study is entirely voluntary. Your relationship with your school, the researcher or Lancaster university or any other organization connected with computing education, will not be impacted by choosing not to take part in this study.

What will you have to do if you take part?

If you agree to take part in this study, you will be asked to take part in short interview taking between 30min and one hour. This interview will be reflecting on the 'initial findings' from my Ph.D. Your answers and feedback will then help shape the final presentation of these findings in my thesis. Prior to the interview you will be sent a short (no longer than one A4 page) summary of my initial finding and a number of key discussion points regarding these findings.

Interviews will be audio recorded and all or portions of the intervews may be transcribed. If you would like a copy of the audio recording or any transcription created, you are welcome to have these.

How will your data be stored and protected?

All data collected in this study will be kept on secure encrypted and password protected digital storage (that is no-one other than me, the researcher will be able to access them). All videos, photographic and audio data will be transferred from any recording device to an encrypted password protected hard drive at the end of each day's observations, and then deleted from the recording device.

There are two forms of data which will be treated as described below. These are **non-anonymised data** and **anonymised data**.

Non-anonymised data (including audio and video content, photographs and data linked to participant names) will be stored until the end of my Phd which should be approximately December 2019, although potentially could take longer. This enables me to analyze the data and produce anonymised forms of it. Only my direct academic supervisors and I will have direct access to this data.

Anonymised data (in which participant names or other identifying attributes have been removed) will be stored for a minimum of 10 years and may be stored indefinitely. For example, audio data is anonymised by transcribing the events in the recording and using pseudonyms to refer to individual people. It is requirement of my funding from the Research Council that anonymised data is stored for this length of time. What I mean by transcription is that what people have said during the recording is written down; make something like script of what has been said. This is sometime done by computer software or in other cases done by a person

For further information about how Lancaster University processes personal data for research purposes and your data rights please visit our webpage: www.lancaster.ac.uk/research/data-protection

How will your data be used?

Anonymised data (including all observed classroom activity, and interview transcriptions) will be used for the completion of my Ph.D. thesis and corresponding academic publications such as papers or conference presentations.

Although I may use direct quotes either from interviews or observations in my thesis or other publications these will be anonymised, before appearing. As previously stated, if I use any photographs or videos in my thesis or other publication, every effort will be made to ensure that individuals are not identifiable.

Non-anonymised data will never be used in this way and will only be used to generate anonymised data.

What are the benefits and risks of taking part?
By taking part in the research you are helping the investigation of the impact of the KS3 computing curriculum. This research will be exploring how the policy intentions which motivate the development of UK curriculum are then delivered through activities in the classroom and the impact this then has on pupils' attitudes towards enterprise, entrepreneurship and the digital economy. The final thesis written from this project will

include policy recommendations about how the computing curriculum could better take its impact on young people into consideration.

The risks of participating in this study are minimal. Your identity will remain confidential and will be anonymised on all project documentation and results, as described above.

What if you change your mind?

You can withdraw from the study at any time. If you withdraw within two weeks from the end of the fieldwork phase of the study (approximately October 1st November 2018), all data that relates exclusively to you will be destroyed (both anonymised and non-anonymised forms). If you choose to withdraw from this study, all recordings and transcripts pertaining to the interview with your will be destroyed. Any insights used in the Ph.D. which are linked exclusively to your interview will also be removed; however, where your insights reflects comments made by others these may still be used (but in no way linked to you).

Withdrawing from this project at any point will not affect any relationship you may have Lancaster University, or any other organisation connected to this project.

Further information

Individuals involved in this study.

Researcher/ Ph.D. Candidate: Benjamin Wohl, HighWire CDT, LICA, Lancaster University, LA1 4WA, b.wohl@lancaster.ac.uk

First Supervisor: DR Lynne Blair, School of Computing and Communications, Lancaster University, LA1 4WA l.blair@lancaster.ac.uk | 01524 510360

Second Supervisor: Professor Martyn Evans, Manchester School of Art, Manchester Metropolitan University, Cavendish St, Manchester, M15 6BG Martyn.evans@mmu.ac.uk | 0161 247 1292

Interviews will only be conducted by Benjamin Wohl.

Concerns or complaints

If you have any concerns or complaints, please contact:

Professor Gordon Blair
Head of Department, HighWire

G.blair@lancaster.ac.uk 01524 510303

This study has been reviewed and approved by Lancaster University's Research Ethics Committee.

Lancaster University InfoLab21
LA1 4WA
Lancaster

Research study:

Preparing young people for the digital economy:
The impact of the English computing as delivered at Key Stage 3

Expert Interview Consent Form

Please tick each relevant box

❑ I confirm that I have read and understood the Participant Information for this study.

❑ I have had the opportunity to consider the information, ask questions about the research and have had these answered satisfactorily.

❑ I agree to take part in the research and understand that my participation is voluntary.

❑ I understand that I can withdraw from the study at any time, and that if I withdraw within two weeks from the end of the fieldwork phase of the study (approximately December 1st 2018), all data that relates exclusively to me will be destroyed (both anonymised and non-anonymised forms). If I withdraw after this point anonymised data will be retained.

❑ I understand that data collected during the course of this study will be stored as described in the participant information sheet.

❑ I agree that anonymised quotations can be used in any publications that arise from this study.

❑ I agree to be interviewed as part of this study.

❑ I agree for any interviews, which are conducted with me to be audio recorded for data collection purposes.
Date:
Name of participant: Participant's Signature:

Appendix III
Teacher Interview Performa

How UK digital economy policy fosters enterprise and entrepreneurship through the Key Stage 3 computing curriculum.

Teacher Interview:

Name__________
Date___________
Have you completed a "teacher consent form"? Yes/No

Overview of the interviews:
The purpose of this interview is to explore with teachers like yourself who are delivering KS3 computing in UK schools (specifically at year 9), how you interpret and deliver the Computing Curriculum. This is a semi-structured interview, which means that although there are few questions listed below these are more 'jumping off points', rather than questions I am looking for specific answers to. I have anticipated that this interview will last slightly less than an hour depending on your answers. However, should you think of anything after the interview that you would like to include please feel free to get in touch (contact details below). Once the Interviews have been transcribed, I will provide you with a 'proof' transcription review, and should you wish to clarify anything you have said, you will be given an opportunity to do so.

I would also like to reiterate that this interview is confidential and not in any way aiming to judge or evaluate you or your teaching. Should I use direct quotations form this interview in any form, every effort will made to ensure that your words are anonymised. The purpose of this interview is to allow your voice as a teaching professional to inform and shape my research.

Purpose of the research:
This research is aiming to understand the process which has informed the shaping of the UK computing curriculum, how this is being interpreted by schools and teaching professionals and the impact it is having on both young people and teachers. Through this interview we will be discussing how you interpret and deliver the computing curriculum and how you feel you are evaluated in this area.

As you know, I will also be looking at various forms of documentation relating to computing in schools. This interview is a chance for me to understand your personal experience and understanding; there are no right or wrong answers. Finally, I want to thank you for your time and honesty. This research would not be possible without the support of teachers such as you.

Interview Questions

CONTEXT

1. **How long have you worked here? How long have you been teaching?**
2. **What did you do before becoming a teacher?**
3. **What is it like to teach at this school, how has that changed over time?**
4. **Has it changed since you first began and if so in when and in what ways?**
5. **How has the overall changes in education policy affected you?**
6. **What do you think of the change of emphasis from ICT to Computing?**
7. **Does it require you to be different?**
8. **How has it changed the teaching profession over all?**

INTERPRETATION

1. Have you heard of the phrase 'computational thinking'? What does it mean to you? What do you think it is meant to mean? What do you see as the role of "computational thinking" within the computing curriculum?
2. What do you think is the main purpose of the change from teaching ICT to teaching the broader subject of Computing?
3. What do you think is the relevance of the computing curriculum for the pupils you teach?
4. Do you think that pupils will use the skills and concepts they learn through the computing curriculum in the future? How?
5. Do you think the computing curriculum will require pupils to be different in any way? If yes, in what ways?

Delivery:

1. What do you think is the most important thing you teach through the computing lessons?
2. Which part of the Computing Curriculum do you feel you spend the most time teaching, for whatever reason?
3. If you could change any aspect about the computing curriculum what would it be?
4. If you could only teach one aspect of the computing curriculum what would it be?
5. Other than those things you have mentioned, is there anything else you would change about the computing curriculum?

Evaluation:

1. How do you feel you are judged and evaluated on your delivery of computing?
2. In terms of evaluation, what are your headteacher/OFSTEDs priorities for computing?
3. What is the hardest aspect of the computing curriculum to deliver, in order to meet the expectations of you as a teacher?
4. If you were asked to observe and evaluate another teacher's delivery of the computing, what would be the key things you would look for?

Impact:

1. To what extent do you think the computing curriculum relates to how pupils in your school use computers in their everyday lives?
2. How would you describe, the degree to which pupils find the curriculum relevant (or not) to their own lives?
3. Do you think that learning computing affects pupils' decisions and choices about their future (if at all)?
4. If I asked your pupils in five years' time (when they are 19 or 20) about learning computing in KS3/4 and what aspect has had the most impact, what do you think/hope they will say?

Teacher Interview Performa, Version 2

How UK digital economy policy fosters enterprise and entrepreneurship through the Key Stage 3 computing curriculum.

Teacher Interview:

Name__________
Date___________
Have you completed a "teacher consent form"? Yes/No

Overview of the interviews:
The purpose of this interview is to explore with teachers like yourself who are delivering KS3 computing in UK schools (specifically at year 9), how you interpret and deliver the Computing Curriculum. This is a semi-structured interview, which means that although there are few questions listed below these are more 'jumping off points', rather than questions I am looking for specific answers to. I have anticipated that this interview will last slightly less than an hour depending on your answers. However, should you think of anything after the interview that you would like to include please feel free to get in touch (contact details below). Once the Interviews have been transcribed, I will provide you with a 'proof' transcription review, and should you wish to clarify anything you have said, you will be given an opportunity to do so.

I would also like to reiterate that this interview is confidential and not in any way aiming to judge or evaluate you or your teaching. Should I use direct quotations form this interview in any form, every effort will made to ensure that your words are anonymised. The purpose of this interview is to allow your voice as a teaching professional to inform and shape my research.

Purpose of the research:
This research is aiming to understand the process which has informed the shaping of the UK computing curriculum, how this is being interpreted by schools and teaching professionals and the impact it is having on both young people and teachers. Through this interview we will be discussing how you interpret and deliver the computing curriculum and how you feel you are evaluated in this area.

As you know, I will also be looking at various forms of documentation relating to computing in schools. This interview is a chance for me to understand your personal experience and understanding; there are no right or wrong answers. Finally, I want to thank you for your time and honesty. This research would not be possible without the support of teachers such as you.

Interview Questions

CONTEXT

1. How long have you been a teacher? How long have you been teaching here?

2. What did you do before becoming a teacher?

3. What is it like to teach at this school, how has that changed over time?

4. Has it changed since you first began and if so in when and in what ways?

5. How has the overall changes in education policy affected you?

6. What do you think of the change of emphasis from ICT to Computing?

7. Does it require you to be different?

8. How has it changed the teaching profession over all?

INTERPRETATION

1. Have you heard of the phrase 'computational thinking'? What does it mean to you? What do you think it is meant to mean? What do you see as the role of "computational thinking" within the computing curriculum?

2. What do you think is the main purpose of the change from teaching ICT to teaching the broader subject of Computing?

3. What do you think is the relevance of the computing curriculum for the pupils you teach?

4. Do you think that pupils will use the skills and concepts they learn through the computing curriculum in the future? How?

5. Do you think the computing curriculum will require pupils to be different in any way? If yes, in what ways?

Delivery:

1. What do you think is the most important thing you teach through the computing lessons?

2. Which part of the Computing Curriculum do you feel you spend the most time teaching, for whatever reason?

3. If you could change any aspect about the computing curriculum what would it be?

4. If you could only teach one aspect of the computing curriculum what would it be?

5. Other than those things you have mentioned, is there anything else you would change about the computing curriculum?

Evaluation:

1. How do you feel you are judged and evaluated on your delivery of computing?

2. In terms of evaluation, what are your headteacher/OFSTEDs priorities for computing?

3. What is the hardest aspect of the computing curriculum to deliver, in order to meet the expectations of you as a teacher?

4. If you were asked to observe and evaluate another teacher's delivery of the computing, what would be the key things you would look for?

Impact:

1. To what extent do you think the computing curriculum relates to how pupils in your school use computers in their everyday lives?

2. How would you describe, the degree to which pupils find the curriculum relevant (or not) to their own lives?

3. Do you think that learning computing affects pupils' decisions and choices about their future (if at all)?

4. If I asked your pupils in five years' time (when they are 19 or 20) about learning computing in KS3/4 and what aspect has had the most impact, what do you think/hope they will say?

Appendix IV

Young Person Interview Performa

How UK digital economy policy fosters enterprise and entrepreneurship through the Key Stage 3 computing curriculum.

Pupil Interview:

Name____________
Date_____________
Have you completed the "group interview" consent form?

Overview of the interviews:
The purpose of this interview is to explore with Year 9 pupils, like you, how you are being impacted and affected through learning computing skills and concepts in school. This will be semi-structured group interview, which means that although there are few questions listed below these are more 'jumping off points', rather than questions I am looking for specific answers to. This interview will be split in to two parts during the first 20 minutes you will be given a chance to discuss the topics as a group (without me present), after the first 20 minutes I will then join you and talk to you about your thoughts and responses to the topics.

This interviewed will be transcribed (what has been said will be typed up into something like a script). If you are interested, once the Interview has been transcribed I can provide you with a transcription to review, and should you wish to clarify anything you have said, you will be given an opportunity to do so. Once the interview has been 'transcribed' I can pass the transcription on to your teacher to you (Should you wish).

I would also like to reiterate that this interview is confidential and not in any way aiming to judge or evaluate your understanding or skill in terms of computing. This interview is a chance for me to understand your point of view and perspective. Should I use direct quotations form this interview in any form, every effort will made to ensure that your words are anonymised (meaning that it will not possible for anyone to know who said the precise quote). The purpose of this interview is to allow your voice as a pupil to inform and shape research in regards to the computing curriculum.

Purpose of the research:
This research is aiming to understand the process which has informed the shaping of the UK computing curriculum, how this is being interpreted by schools and teaching professional and the impact it is having on both young people and teachers. Through this interview we will be discussing how you use computers in your day life, how you think you will use computers in the future and what you feel the impact of the computing curriculum is.

This interview is a chance for me to understand your personal experience and understanding; there are no right or wrong answers.

Finally, I want to thank you for your time and honesty. This research would not be possible without the support of pupils such as you.

Benjamin Wohl M.A. M.Res.
HighWire CDT,
Lancaster University
b.wohl@lancaster.ac.uk

Group Discussion

Please look at the following discussion prompts, spend a few minutes discussing each one.

How do you use computers now?

1. Can you name three computer scientists, or people who have influenced the field of computing?
2. What sort of a person do you think is good at computing?
3. How would you complete the following sentence: "Computers are for..."?
4. To what extent do you agree or disagree with the following statement:
    a. "I am the same person when I am online, as I am when I am offline."
    b. "I say things online that would not say offline."
    c. "How much a person knows about computers, changes how they interact with other people when online."

How do you think you will use computers in the future?

1. In 10 years' time what do you think the "digital world" will look like?
2. What do you think will be possible (in computing terms) in the future that is not possible now?
3. How much of your time do you think you will spend using a computers or digital devices when you are an adult?

What do you think the impact of the computing curriculum is on you?

1. Do you think your computing lessons require you to change, this could be as a person, or how you think, or how you behave? If yes, how? in what ways?
2. What do you think is the main purpose of you learning computing and about computers in school?
3. To what extent do you think that what you have learned in your computing classes relates to how you use computers in your everyday lives? What about how you will use computers in the future?
4. What would make your computing lessons more engaging or exciting?

Interview Questions

These are questions I will cover in the second half of the interview, feel free to read them and think about your answers beforehand.

How do you use computers now?

1. Do your lessons require you to think in a different way?
2. What does the term 'Computational thinking' mean to you?
3. Do you have your own computer at home? How many computers in total are there in your home?
4. How much time do you feel like that you spend using computers or digital devices during an average day? What is it you spend your time doing on these devices?
5. What does the term "social media" mean to you? Do you use any social media, how much time do you spend using social media?
6. Do you consider yourself to be part of any online communities or groups, (such as online guilds, specialist forums)?

How do you think you will use computers in the future?

1. When you are an adult, how important do you think it I will be to understand how computers and software works?
2. How do you think you will use computers in the future? At work? In your house? How about for hobbies, sports, and play?
3. In 5 years' time what do you think you will remember or use from what you have learned about computing in school?

What do you think the Impact of the computing curriculum is on you?

1. Can you tell me about how you feel your work in computing is assessed, graded, or marked? What sort of work gets you good marks, what would result in you getting poor marks? Is there anything that is 'completely unacceptable' in terms of your computing course work?
2. If you don't think you are very good at computing, what do you think you could do to improve? How will doing this change you as a person (if at all)?
3. In what way would you say learning about computing has affected your choices and decisions about the future?
4. Is there anything you should be learning about computing and computers but isn't covered in your computer lesson?