Pye Tait Consulting

THE ROYAL SOCIETY

After the Reboot: The State of Computing Education in UK Schools and Colleges

Final Report

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Executive Summary

Background

The Royal Society's 2012 report, '*Shut down or restart?*', concluded that computing education in many UK schools was unsatisfactory, due to a lack of specialist teachers, a broadly interpreted curriculum, lack of Continuing Professional Development (CPD) and inadequate infrastructure[1]. In the same year, the then Education Secretary, Michael Gove, announced the withdrawal of ICT in favour of a radical new computing curriculum for 5-16 year olds in England. The new curriculum, introduced in September 2014, established computer science and computational thinking[2] as a core subject alongside others such as English, mathematics and the sciences.

In 2016, almost two years on from the introduction of the new curriculum in England, The Royal Society launched a UK-wide programme of work to gather evidence about the state of computing education. This took into account devolved educational policy and the separate curriculum arrangements in each of the four nations. The three-package programme of work incorporated a literature review to examine effective computing pedagogy and assessment methods, a quantitative and qualitative study of computing practice in schools (the subject of this research), and, thirdly, a review of attainment data. Collectively the evidence will inform the next stage of the programme, which, looking forward from 2017, intends to develop fresh support for schools and colleges.

The Royal Society commissioned Pye Tait Consulting to undertake research into computing practice in UK schools and colleges, involving an online survey run concurrently with eight small discussion groups, followed by eight case study school visits. The research spanned four main areas:

- Participation, profile and attainment of students in computing education;
- Teacher expertise, including the profile and background of computing teachers, their knowledge, confidence and participation in Continuing Professional Development (CPD);
- The learning environment, including how computing is coordinated and resourced, and the use of external support; and
- Widening access, including steps taken by schools to increase participation among girls and other groups of students who might otherwise experience difficulties engaging with the subject.

The online survey obtained 341 responses from primary school teachers (329 unique schools) and 604 responses from secondary school/college teachers (562 unique institutions) across the UK. Whilst every effort was taken to deliver a representative sample, the self-completion nature of this

[1] The Royal Society (2012) *Shutdown or restart? – The way forward for computing in UK schools*

[2] Computational thinking involves taking a complex problem and breaking it down into a series of smaller parts. Simple steps or rules (algorithms) are then created to solve each part. Finally, these algorithms are used to program a computer to help solve the complex problem in the best way.

large-scale quantitative survey mean that it has not been possible to eliminate the risk of bias, particularly towards those who have stronger understanding and favourability towards the computing curriculum. This is discussed in more detail in Appendix A1.3.

Summary of Research Findings

The following findings are based on the views of surveyed teachers.

Main benefits of computing education as perceived by surveyed teachers:

- ✓ Underpins the UK's future growth in a fast-paced and evolving digital sector.
- ✓ Teaches valuable and transferrable problem-solving skills through computational thinking.
- ✓ Provides creative teaching opportunities through a range of resources which can be accessed free or at relatively low cost.
- ✓ Offers cross-curricular links, e.g. 'debugging' sentence structures in English and helping to tackle and break down maths problems.
- ✓ Pupils can learn while having fun, such as through national coding competitions and school robotics clubs, and teachers can also learn and develop from the students themselves.
- ✓ Creates additional opportunities for links with industry, such as through work experience.

Primary Schools – Key facts from the survey

Teaching Expertise

52% of surveyed teachers rated their understanding of computational thinking with a score of at least 8 out of 10. Scores were received from across the spectrum from 1 'no understanding' to 10 'complete and full understanding'. Ratings are significantly higher among those teachers who hold their highest qualification in computer science, compared to those qualified in another discipline.

65% rated their favourability towards the new computing curriculum with a score of at least 8 out of 10. Again scores were received from across the range from 1 'not at all favourable' to 10 'completely favourable'.

7% of responding primary teachers hold their highest qualification in computer science.

The most commonly reported number of computing-related CPD hours is zero (28% of respondents). A variety of CPD-related activities were reported and are discussed in the main report.

The Learning Environment

The majority of responding primary schools (84%) have a designated lead teacher of computing education.

In most surveyed schools, pupils receive 1 hour of computing education per week.

There are disparities between schools as to whether levels of investment in computing (£ and time) have increased/decreased/stayed the same over the past three years.

Suitability of school equipment and other physical resources for computing is rated on average at 6.7 out of 10. A full range of scores were received in the survey, from 1 'poor' to 10 'excellent').

Extra-curricular (informal) computing activities are offered by 62% of surveyed schools, with the most common being weekly computing clubs.

The most helpful reported resources include CAS Barefoot, Scratch and Rising Stars.

Secondary Schools – Key Facts from the Survey

Teaching Expertise

75% of surveyed teachers rated their understanding of computational thinking with a score of at least 8 out of 10. Scores were received from across the spectrum from 1 'no understanding' to 10 'complete and full understanding'. As is the case among primary schools, ratings are significantly higher among those teachers who hold their highest qualification in computer science, compared to those qualified in another discipline.

38% rated their favourability towards the new computing curriculum with a score of at least 8 out of 10. Again scores were received from across the range from 1 'not at all favourable' to 10 'completely favourable'.

36% of responding secondary teachers hold their highest qualification in computer science.

The most commonly reported number of computing-related CPD hours is zero (26% of respondents) and almost all CPD is undertaken in teachers' own time. A variety of CPD-related activities were reported and are discussed in the main report.

Widening Access

Encouraging girls' interest in computing is perceived by teachers to be easier in primary schools, and that more pronounced gender stereotypes are formed during secondary years, which can be harder to overcome.

Teachers find that some less able students struggle with computational thinking, but the experimental aspects of the subject, where making mistakes is part of the process, help to make computing unique and appealing for students.

The Learning Environment

The majority of responding secondary schools (88%) have a department that specifically teaches computing education. The remainder teach computing as part of another faculty, most commonly combined with business studies, technology or maths.

Non-specialist teachers of computing are drawn from a range of other subject backgrounds, most commonly business studies, maths and design & technology.

In most surveyed schools, students receive 1 hour of computing education at Key Stage 3 (England/Wales) and 1 hour at levels S1/S2 (Scotland).

Most surveyed secondary schools have experienced a decrease in the level of investment in computing (£ and time) over the past three years.

Suitability of school equipment and other physical resources for computing is rated 6.9 out of 10. A full range of scores were received, from 1 'poor' to 10 'excellent').

At least some form of extra-curricular computing activity is offered by 77% of responding schools, with the most common being weekly computing clubs.

Top 10 obstacles faced by teachers

Each of the following obstacles was mentioned by a minority of research participants (i.e. across the survey, discussion groups and case studies) but they are ranked below from most to least cited.

1. **Subject knowledge:** Whilst just over half of surveyed primary teachers and three quarters of secondary teachers rated their own understanding of computational thinking with a score of at least 8 out of 10, a lack of subject-specific technical knowledge (e.g. coding and programming) was the single most commonly reported barrier mentioned by respondents in the wider context of their school, including colleagues responsible for teaching at least some aspect of the subject.

2. **CPD:** Some teachers say that they don't have enough time in their working day for computing-related professional development and that other commitments, such as marking and lesson planning, already place high demands on their time out of school hours.

3. **Teaching resources:** There are reported difficulties being able to identify and select good quality resources covering teaching materials and content.

4. **Funding:** Some schools have insufficient funding to acquire the types of equipment and software needed to deliver the curriculum effectively.

5. **Curriculum focus:** There is concern among some teachers that the new computing curriculum in England focuses too strongly on computer science at the expense of ICT, which is still considered important for students to develop skills that are vital for life and work (such as keyboard and spreadsheet skills). This concern is exacerbated by the withdrawal of GCSE and A level qualifications in ICT (with final awards for these subjects taking place in summer 2018).

6. **Senior leaders:** A lack of buy-in to computing among senior school leaders can have a knock-on impact on funding, resourcing and access to high quality CPD.

7. **Performance benchmarks:** Lack of clarity around performance benchmarks for GCSE and A level Computer Science qualifications is making it difficult for schools to measure students' progress and make grade predictions.

8. **GCSE and A level specifications:** There is a view that GCSE and A level Computer Science specifications contain too much content.

9. **Mixed abilities:** Being able to support mixed ability students in one class can prove a challenge, i.e. stretching the most able and not alienating less able students for whom computational thinking could prove extremely difficult.

10. **Inconsistencies:** Two case study schools and several focus group participants described disparities in the abilities of students starting in the first year of secondary school, which they put down to variations in the level of computing education among feeder primary schools.

Top 10 support needs of teachers

Each of the following support needs are ranked from most to least cited, and in some cases were mentioned by research participants in the wider context of their school and their colleagues, i.e. to strengthen overall capacity and capability.

1. **More training**, such as face-to-face workshops and seminars, where teachers (particularly non-specialists), can develop their understanding of computing theory and technical competence in using equipment and gadgets. This

2. **Dedicated time for training and CPD** to ensure this is undertaken consistently and effectively (including re-training of subject teachers without a background in computing but who need to teach the subject).

3. **More specialist expertise** to help with computing education in schools, such as recruitment of suitably qualified and experienced computing teachers, involvement of volunteers, university students, guest speakers etc.

4. **Networking, collaboration and mentoring opportunities** in conjunction with other educational institutions, businesses and relevant bodies, to help develop own knowledge, share ideas and best practice.

5. **Easier access to the right teaching resources (**high quality and low cost/free), such as lesson plans and effective pedagogy.

6. **Better equipment for use in schools**, such as laptops, netbooks, tablets, and robotics, as well as suitable learning spaces where students can balance desk-based and computer-based work.

7. **More funding** for schools to be able to invest in training, teaching resources, infrastructure and equipment.

8. **A higher profile for computing education**, particularly to influence senior leadership teams and parents.

9. **Clearer performance and assessment benchmarks** from exam boards, including provision of more and better support and guidance.

10. **Curriculum clarity,** on how to interpret and meet the requirements of the new computing curriculum in England.

Teacher Profiles

Based on the survey findings, it has been possible to develop a set of four broad teacher profiles. These have been defined based on the combination of how teachers rated their 'understanding of computational thinking' (from 1 to 10) in relation to their 'favourability towards the computing curriculum' (also from 1 to 10). The details and typical characteristics of each profile are set out in Table 1.

Due to the self-selecting nature of the online survey (discussed above and in Appendix A1.3), the percentage of surveyed teachers captured by each profile is not necessarily representative of the wider teaching population. Furthermore the profiles should not be considered completely rigid as some teachers may not fully identify with the characteristics of any one group. Further details about the formation of the profiles is explained in section 3.1.3.

Table 1 Teacher profiles – definitions and typical characteristics

Profile	Definition (based on the combination of 'understanding' and 'favourability')	Typical characteristics (albeit does not apply to all respondents within each group)
Advocates profile **Strong understanding of computational thinking and high favourability towards the computing curriculum.** **54% of surveyed teachers**	Rating of understanding of computational thinking: At least 7 out of 10 Rating of favourability to the new computing curriculum: At least 7 out of 10	The strongest advocates are generally confident in their ability to deliver the computing curriculum. They tend to hold their highest qualification in computer science (secondary schools), commit the highest number of hours to computing-related CPD, and have engaged in CAS-related CPD. Advocates are likely to be important influencers within and between schools, instrumental to helping supporters to improve their knowledge and understanding, and better engaging critics by helping to strengthen their buy-in.
Supporters profile **Comparatively less understanding of computational thinking but high favourability towards the computing curriculum.** **8% of surveyed teachers**	Rating of understanding of computational thinking: Less than 7 out of 10 Rating of favourability to the new computing curriculum: At least 7 out of 10	Supporters are generally less confident than Advocates and Critics in delivering the computing curriculum. They hold a mix of qualifications and show mixed levels of commitment to computing-related CPD. With additional support from advocates to improve their knowledge and understanding, these teachers have the potential to be advocates of the future.

Critics profile **Strong understanding of computational thinking but comparatively low favourability towards the computing curriculum.** **24% of surveyed teachers**	Rating of understanding of computational thinking: At least 7 out of 10 Rating of favourability to the new computing curriculum: Less than 7 out of 10	Critics are generally less confident than Advocates in delivering the computing curriculum, which may be a causal factor for being comparatively less favourable to the curriculum. They hold a mix of qualifications and show mixed levels of commitment to computing-related CPD. This group is typically well-placed to deliver the new computing curriculum but stronger buy-in is generally needed.
Less Engaged profile **Comparatively less understanding of computational thinking and comparatively low favourability towards the computing curriculum.** **14% of surveyed teachers**	Rating of understanding of computational thinking: Less than 7 out of 10 Rating of favourability to the new computing curriculum: Less than 7 out of 10	Less Engaged teachers are comparatively less confident in delivering the computing curriculum than the other groups. This group mainly consists of teachers who hold their highest level qualification in a discipline unrelated to computing, science or maths. Commitment to computing-related CPD hours is also comparatively lower. This group of teachers may be less likely to take a proactive approach to delivering computing curriculum and more work is needed to encourage buy-in and develop subject knowledge.

Key Findings

Further details underpinning each of the following key findings is provided in section 7, including signposting to the main evidence in the report.

1. The new computing curriculum in England is generally welcomed by teachers participating in the research, although schools/colleges appear to be on a long term journey to developing and delivering effective learning. This is especially the case given that some schools have not yet fully 'transitioned' from offering GCSE/A level ICT to equivalent qualifications in Computer Science, and evidence that the subject is being delivered in some schools by a combination of specialist and non-specialist teachers.

2. There is evidence of a shortage of suitably skilled and qualified computing teachers, particularly in secondary schools, with the risk that this situation could worsen in the future if additional support is not put in place.

3. Teachers believe that the new computing curriculum in England has been introduced with insufficient guidance around whom would teach the subject and how training, CPD and other guidance for teachers could take place.

4. Variations in computing budgets and the suitability of physical resources and infrastructure in schools points to disparities in the opportunities for teaching and learning computing.

5. Following its introduction, some teachers remain concerned the new computing curriculum in England risks placing too much emphasis on computer science at the expense of ICT and digital literacy being marginalised.

6. Variations in the abilities of computing students entering secondary school appears to be affected by current disparities in the level of understanding, favourability and confidence in computing education among feeder primary schools;

7. Participation in computing education appears to be improving among girls, but some schools are being more proactive than others in widening access and broadening the appeal of the subject to different groups of learners;

8. Finally, there are some excellent examples from the discussion groups and case studies of transferrable best practice from schools that have successfully embedded computing education to date, including computer science.

Recommendations are not included within this report. These have been developed separately by The Royal Society based on the findings from all three separately delivered Work Packages.

1. Introduction

1.1 Rebooting Computing Education

For the UK to be a world-leading digital economy that works for everyone, the Government is committed to everyone having the digital skills they need to fully participate in society[3].

Computing underpins almost all aspects of the modern world and many new developments in science and engineering could not have been realised without it. Some of the UK's most eminent stars in this field have included Ada Lovelace, Alan Turing, and more recently Sir Tim Berners-Lee who is credited as the inventor of the World Wide Web. Today's UK computer scientists are working in fields as diverse as high-tech medical applications, cube satellites, GPS farm robotics and autonomous vehicles. Computing is also fundamental to our national defence, with the need to ensure the safety and security of cyberspace an essential requirement for the entire digital economy[4].

The 'digital economy' alone is complex to define and measure, research carried out by the National Institute of Economic and Social Research (NIESR) suggests that it comprises 14% of active companies in the UK. This goes far beyond the likes of dot.com or biotechnology start-ups, but extends across all corners of industry, from architecture firms, whose activities have become almost entirely digital, to machine tool manufacturers who now use huge online data-processing facilities to monitor every aspect of their processes[5]. Qualifications in computer science therefore have the potential to underpin today's digital, and possibly tomorrow's quantum, society, and to prepare students for rewarding careers in world-changing innovations.

Computer science largely disappeared from schools in the 1990s and early 2000s in favour of *Information and Communication Technology (ICT)*, which focused on the 'use' of technology and software rather than its creation and on the underlying principles of computation. But since the late 2000s, a mixture of pressure from industry and lobbying by interest groups has led to resurgent interest in computer science for developing essential transferable skills (often referred to as 'computational thinking'), along with valuable knowledge and skills for a modern tech-driven world[6].

In a speech at the 2012 annual British Educational Training and Technology Show (BETT), the then Education Secretary, Michael Gove, described computer science as *"a rigorous, fascinating and intellectually challenging subject, requiring a thorough grounding in logic, and merging increasingly with other scientific fields such as computational biology".* He added that *"whilst technologies*

[3] Department for Culture, Media and Sport (2017) *UK Digital Strategy*
[4] Ibid.
[5] NIESR (2013) *Measuring the UK's Digital Economy with Big Data*
[6] ACM (2013) *Restart: The Resurgence of Computer Science in UK Schools*

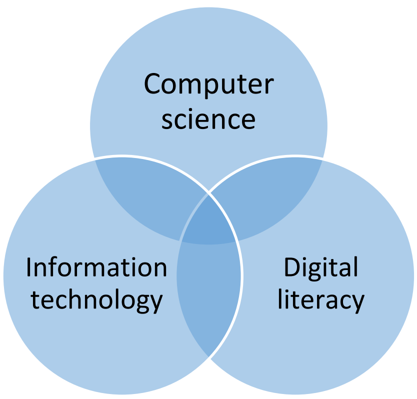
evolve, the foundational concepts and principles that underpin them will still hold true and remain relevant for students through their working lives".

In its 2012 report '*Shut down or restart?',* The Royal Society concluded that existing computing education[7] in many UK schools was unsatisfactory for reasons such as non-specialist teachers, a broadly interpreted curriculum, lack of Continuing Professional Development (CPD) and inadequate infrastructure[8]. Drawing on the findings from '*Shut down or restart*?', and in association with sector experts convened by the British Computer Society and the Royal Academy of Engineering, the Education Secretary announced the withdrawal of ICT in favour of a radical new computing curriculum for 5-16 year olds in England. The new curriculum established computer science and computational thinking (explored further in section 3.1) for the first time anywhere, as a core subject alongside mathematics and the sciences.

The Royal Society is committed to supporting effective teaching of the school and college computing curricula across the UK (5-18 year olds) Its programme of work to gather and share evidence about how this is being delivered in practice will lead to the development of support for UK schools and colleges, which may include:

- Classroom resources, teacher guidance, and CPD programmes;
- Effective assessment tools that teachers can use to understand and guide progress;
- Guidance about how to address gender imbalance in the uptake of computing; and
- Opportunities for project work in schools, perhaps with corporate partners[9].

To inform its work, the Society has identified three distinct and complementary components of computing:



[7] From this point forward, the term 'computing' or 'computing education' is used as a generic term to refer to the curriculum and course offers in each of the devolved nations.
[8] The Royal Society (2012) *Shutdown or restart? – The way forward for computing in UK schools*
[9] Source: The Royal Society [online] 'Computing Education'. Available at: https://royalsociety.org/topics-policy/projects/computing-education/

Whilst there is no single accepted 'definition' for each component, Computing At School defines each one as follows:

- **Computer science:** Covers the scientific and practical study of computation, i.e. what can be computed, how to compute it, and how computation may be applied to the solution of problems;
- **Information technology:** Concerned with how computers and telecommunications equipment work, and how they may be applied to the storage, retrieval, transmission and manipulation of data; and
- **Digital literacy**: The ability to effectively, responsibly, safely and critically navigate, evaluate and create digital artefacts using a range of digital technologies[10].

Further details about how computing education is interpreted in UK education curricula are explained in the next section.

1.2 Computing Curricula in the UK

Educational policy is devolved in the UK and each of the four UK nations operates its own curriculum. A summary of current arrangements and recently announced changes to computing education in each nation is set out below. A supporting matrix of school ages and years (for reference) can be found in Appendix A4.

[10] Computing at School (2014) *Computing in the National Curriculum – A Guide for Secondary Teachers*

England:	Scotland:
New National Curriculum for Computing, introduced from September 2014	Curriculum for Excellence – Technologies (refreshed as part of the 2016 Digital Learning and Teaching Strategy for Scotland)
The new computing curriculum is non-prescriptive and there are no specified coding languages, software or hardware to use. From age 5, pupils are taught the principles of information and computation and how digital systems work. They go on to learn how to put this knowledge to use through programming. Building on this, pupils are equipped to use information technology to create programs, systems and a range of content. At Key Stage 4 (equivalent to GCSE), all pupils must have "the opportunity" to study aspects of information technology and computer science. As part of a wider programme of qualifications reform, revised AS and A Levels in Computer Science have recently been introduced into schools. GCSE qualifications in ICT have been withdrawn and will no longer be offered from September 2017.	The Scottish Government introduced the Curriculum for Excellence in 2010-11. This set out to help children and young people gain the knowledge, skills and attributes needed for the 21st century. The 'Technologies' area sets out experiences and outcomes for students in a range of contexts spanning: Business; Computing Science; Food and Textiles; and Craft, Design, Engineering and Graphics As part of the 2016 *Digital Learning and Teaching Strategy for Scotland*, the Scottish Government has refreshed the experiences and outcomes in the Technologies area of the Curriculum for Excellence. This includes discrete units covering (among others): Digital Literacy; Computer Science; and Technological Developments in Society (including Business Education).
Source: Department for Education	*Source: The Scottish Government*

Wales:	Northern Ireland:
The 2008 National Curriculum for Information and Communication Technology (ICT) is due to be replaced by a new Curriculum for Life, including aspects of computer science. The current ICT curriculum in Wales applies to pupils from Key Stage 2 (ages 7-11) to Key Stage 4 (ages 14-16) in maintained schools. Learners develop their ICT skills by finding, developing, creating and presenting information and ideas and by using a wide range of equipment and software. In September 2016, a new Digital Competence Framework was made available for schools and other settings in Wales, making it the responsibility of all teachers and practitioners to include digital competence within lessons. The new Curriculum for Life is expected to be launch from September 2018. This will include six 'Areas of Learning and Experience'. One of these will (Science and Technology) will include computer science. *Source: Welsh Government*	'Using ICT' is embedded across the Northern Ireland Curriculum Across the Northern Ireland Curriculum in primary and secondary schools, pupils are expected to develop the skills of 'Using ICT' by engaging in meaningful research and purposeful activities set in relevant contexts. They should use ICT to handle and communicate information, solve problems, pose questions and take risks. They should process, present and exchange their ideas and translate their thinking into creative outcomes that show an awareness of the audience and purpose. They should also use ICT to collaborate within and beyond the classroom, to share and exchange their work. At a level appropriate to their ability, pupils are expected to develop their ICT skills in five key areas, that is to: Explore; Express; Exchange; Evaluate; and Exhibit. *Source: Department of Education (Northern Ireland)*

1.3 Informing Future Support

In 2016, The Royal Society launched an important multi-strand programme designed to improve the quality, scale and effectiveness of computing education in schools and colleges across the UK. This consisted of three work packages:

1. A literature review of effective computing pedagogy and effective assessment of computing;
2. Quantitative and qualitative research among UK schools and colleges to examine the present state of computing education in schools; and
3. A baseline study on participation and attainment data.

The programme is rooted in ongoing dialogue with the teaching profession and though partnerships with expert organisations such as the British Computer Society (BCS), Computing at School (CAS), the Royal Academy of Engineering and global organisations such as Microsoft and Google.

The resulting evidence base will inform advice about the development of new support for schools and colleges, such as:

- Classroom resources, teacher guidance, and CPD programmes;
- Effective assessment tools that teachers can use to understand and guide progress;
- Guidance about how to address gender imbalance in the uptake of computing; and
- Opportunities for project work in schools, perhaps with corporate partners.

1.4 Research Objectives and Approach

1.4.1 Research Objectives

The Royal Society commissioned Pye Tait Consulting to lead on work package 2 (see section 1.3) and this report presents the results of that research. The research spanned four main areas:

- Participation of students in computing, including non-compulsory education (GCSEs and A levels) and informal (i.e. extra-curricular) activities;

- Teachers and teaching, including the profile and background of computing teachers, their knowledge, confidence and attitudes relating to computing education (especially the new curriculum in England), and participation in Continuing Professional Development (CPD);

- The learning environment, including how computing is coordinated and resourced, as well as the use of external support;

- Widening access, including steps taken by schools to increase participation among girls and other groups of students who might otherwise experience difficulties engaging with the subject.

1.4.2 Summary of approach and overview of survey responses

The main research tool was an online survey of UK primary and secondary schools/colleges, aimed at teachers with at least some responsibility for delivering computing education. The survey was supplemented by eight small discussion groups among teachers, hosted in various locations across the UK, as well as eight school case study visits to identify best practice in teaching and learning of the subject.

Total survey responses (by level and nation) are summarised in Table 2. The survey is broadly representative by UK nation at secondary level, although this proved more challenging at primary level. More detail on sampling is set out in Appendix A1 (including Tables 19 and 20).

Whilst every effort has been made to minimise the effect of self-selection bias in the survey (i.e. where schools more favourable to computing may be more predisposed to complete the survey) this has inevitably been impossible to avoid. Further details about the steps considered and taken to minimise this risk are set out in Appendix A1.3.

Table 2 Total survey responses

Nation	PRIMARY – Total responses	PRIMARY – Unique schools	SECONDARY – Total responses	SECONDARY – Unique schools/colleges
England	297	285	526	490
Scotland	38	37	46	44
Wales	4	4	18	16
Northern Ireland	2	2	14	12
Total	**341**	**329**	**604**	**562**

1.4.3 Analysis and reporting

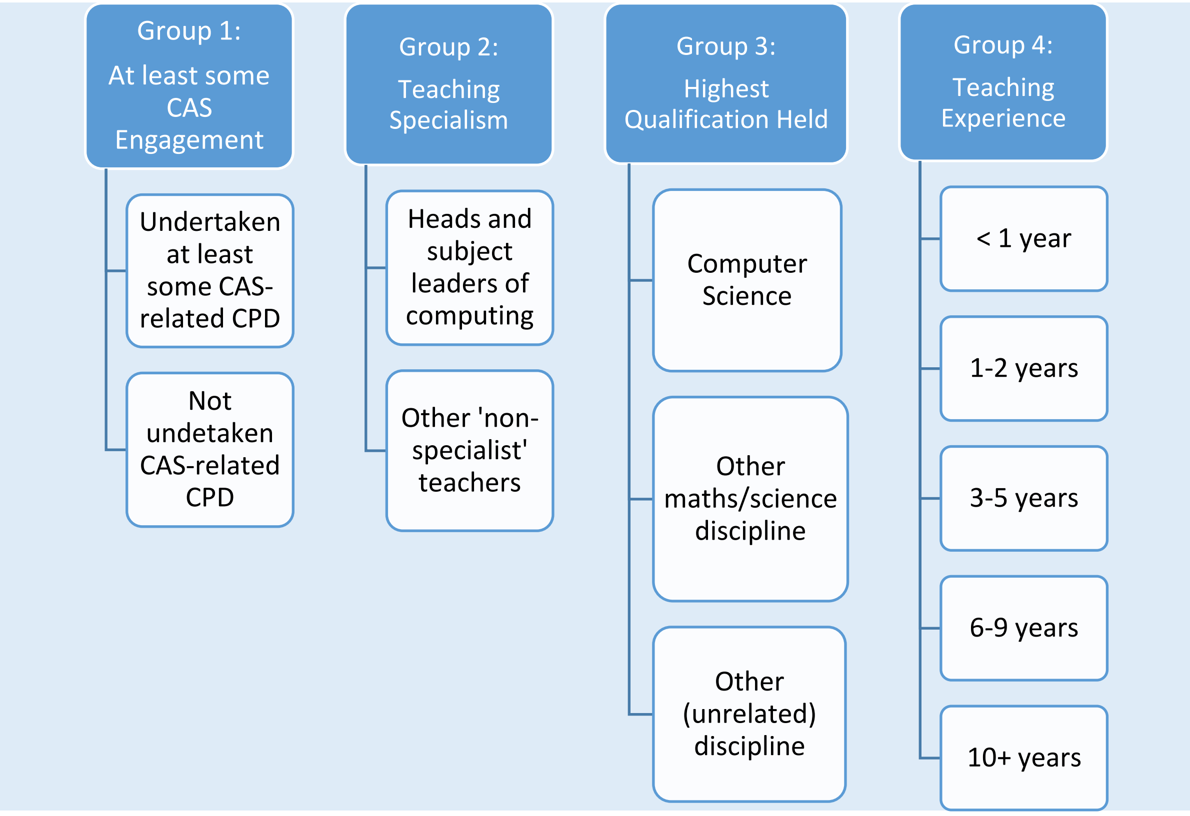
The findings within this report describe responses to the online survey, small discussion groups and case study visits. Different tools are used to achieve this, including computing percentages, averages and (where appropriate) cross-tabulations by key sub-groups.

The sub-groups derived for the analysis of both primary and secondary school/college survey data are shown in Figure 1. In addition, certain questions at secondary level have been cross-tabulated by nation (England/Scotland/Wales/Northern Ireland).

Additionally, for vital topics relating to teaching expertise, statistical testing has been performed to evaluate possible differences between respondent sub-groups. This means that, in addition to describing differences found in the sample via percentages and averages, the differences in distributions have been tested to assess whether they were produced by chance or whether they represent meaningful differences between the sub-groups.

Footnotes are included throughout this report to indicate where statistical tests have been performed and the full suite of tests and their results are set out in Appendix A5.

Figure 1 Respondent sub-groups[11]



In addition to the above categories, analysis of survey responses from England has enabled the development of a set of four teacher profiles. These are introduced in section 3.1.3 and analysis of certain findings from that point forward reveal further characteristics about each profile.

Additional information about the survey respondent profile and associated base numbers can be found in Appendix A2.

[11] Computing at School (CAS) is a membership organisation providing professional practice for computing teachers and promoting excellence in computer science education. For the purpose of this research, CAS engaged respondents are those who have undertaken computing-related CPD in at least one of the following areas in 2015/16: CAS toolkits (e.g. Quickstart), CAS Barefoot workshops and CAS Master Teacher training

2. Computing-Related Qualifications

For surveyed secondary schools and colleges, this section sets out the total (and percentage mix) of student entries to computing-related qualifications in 2015/16[12].

Two separate datasets have been used in order to provide as fully rounded a picture as possible. This is important as each offers different strengths and limitations in the context of this research. In view of this, the datasets are not directly comparable due to differences in the geographical scope, qualification listings and approaches to categorisation.

- Section 2.1 draws on qualifications data attained from the National Pupil Database (NPD)[13]. It covers qualifications offered at Key Stage 4 and Key Stage 5 but is limited to England only.

- Section 2.2 draws on qualifications data from the survey of secondary schools and colleges The resulting data are therefore limited to institutions responding to the survey but coverage is provided of qualifications offered across England, Wales and Northern Ireland[14]. It should be noted that the data from the survey only apply to qualifications offered at Key Stage 4.

2.1 NPD Data (England Only)

Based on data from the National Pupil Database (NPD), schools in England offer a variety of computing-related qualifications, accredited by a range of awarding organisations.

More than a third of GCSE/AS/A level entries in 2015/16 (36%) were for qualifications in the NPD category of Computer Appreciation/Introduction. This is followed by just under a quarter (24%) in the category of ICT and a slightly lower proportion (22%) relating to Computer Studies/Computing (Table 3).

The data should be read in conjunction with the master table provided in Appendix A3, which provides a more detailed breakdown of qualifications within each NPD category, along with total entrants among surveyed schools.

[12] Only applicable for those schools that provided a Unique Provider Reference (URN) or post code to enable data matching to take place.
[13] NPD data used for this purpose relate to students in Key Stage 4 (GCSE/equivalent) and Key Stage 5 (AS/A level/equivalent), for England only.
[14] Students in secondary schools in Scotland follow qualifications that are accredited by the Scottish Qualifications Authority (SQA). Graded computing-related qualifications include National 5, Advanced and Advanced Higher qualifications in Computing Science. Other, smaller, qualifications, such as National Certificates and National Progression Awards, include a broader range of computing-related titles, such as Cyber Security, Digital Media Animation and Internet Technology to name but a few.

Table 3 Computing-related qualifications and student entries (summary NPD data for surveyed schools)[15]

NPD qualifications category	Total entries	Percentage mix
Computer Appreciation/Introduction	15,860	36%
ICT	10,721	24%
Computer Studies/Computing	9,806	22%
Applied ICT	5,610	13%
Computer Architecture/Systems	1,452	3%
Office Technology	1,158	3%
Systems/Network Management	1	0%
Total	**44,607**	**100%**

2.2 Survey Data (England, Wales and Northern Ireland)

This alternative approach to examining computing-related qualification entries for surveyed schools and colleges uses information gathered from the survey itself and covers England, Wales and Northern Ireland.

Based on 308 schools/colleges that provided qualifications data, almost all (94%) reported that they offer more than one computing-related qualification. In 2015/16, the most popular of these was the OCR GCSE in Computing/Computer Science (8,670 total entries, representing a 29% share). This was followed by the BCS Level 2 Electronic Computer Driving Licence (6,926 entries /23% share) and the OCR Level 1/2 Cambridge National Certificate in ICT (2,798 entries /9% share).

A total of 66 surveyed schools (13%) reported entries for GCSE ICT qualifications accredited by the main awarding organisations covering England, Wales and Northern Ireland (AQA, CIE, CCEA, Edexcel, OCR and WJEC). Most offered these alongside computer science-based qualifications, although 24 schools (5% of all those surveyed) reported ICT entries but none for computer science-based programmes.

The mix of entries is shown in Table 4. For ease of reference, GCSE Computer Science qualifications are highlighted in yellow and GCSE ICT qualifications are highlighted in green.

Table 4 Computing-related qualifications and total student entries (surveyed schools)[16]

[15] Schools/colleges in England only 2015/16.

Qualification Title	Total entries	% mix	Qualification Title	Total entries	% mix
OCR GCSE Computing/Computer Science	8,670	28.5%	OCR GCSE ICT	122	0.4%
BCS Level 2 ECDL Certificate in IT Application Skills	6,926	22.8%	Microsoft Office Specialist Qualifications	120	0.4%
OCR Level 1/2 Cambridge National Certificate in ICT	2,798	9.2%	OCR Creative iMedia	203	0.7%
AQA GCSE Computer Science	2,649	8.7%	AQA GCSE ICT	116	0.4%
Edexcel GCSE ICT	2,568	8.4%	CIE IGCSE ICT	100	0.3%
Pearson Edexcel Level 1/2 Certificate in Digital Applications	1,432	4.7%	BTEC Extended Diploma in IT	36	0.1%
Edexcel GCSE Computer Science	1,141	3.8%	OCR Cambridge Technical Introductory Diploma in IT	18	0.1%
Pearson BTEC Level 1/2 First Award in Information and Creative Technology	1,064	3.5%	NCFE Creative Studies Interactive Media	17	0.1%
WJEC GCSE Computer Science	616	2.0%	Eduqas GCSE Computer Science	15	0.0%
WJEC GCSE ICT	525	1.7%	Pearson Edexcel Level 1/2 Diploma in Digital Applications	11	0.0%
CCEA GCSE ICT	501	1.6%	City & Guilds Level 2 Certificate for IT Users	3	0.0%
CIE IGCSE Computer Science	359	1.2%	City & Guilds Level 2 Certificate For Software Developers	0	0.0%
TLM Level 2 Certificate in Open Systems Computing (QCF)	197	0.6%	NCFE Level 2 Certificate in Creative Studies: Computer Technology	0	0.0%
AQA Functional Skills ICT	196	0.6%			

2.3 Chapter Summary

[16] Schools/colleges in England, Wales and Northern Ireland only 2015/16.

Secondary schools/colleges offer a range of computing-related qualifications, including GCSEs and A levels in computer science and/or ICT, as well as more specialised Awards and Certificates. Among surveyed schools in England, Wales and Northern Ireland, the OCR GCSE in Computing/Computer Science is the most popular (accounting for the highest share of students entrants in 2015/16), followed by the BCS Level 2 Electronic Computer Driving Licence (ECDL) Certificate in IT Application Skills.

GCSE and A level qualifications in ICT are being phased out in England (final awards for these qualifications are taking place in summer 2018). At the time of writing, many schools are therefore in the process of transitioning away from ICT qualifications in favour of Computer Science. It is the impact of this transition (i.e. an anticipated reduction in the number of GCSE and A level ICT entries and a rise in the number of equivalent Computer Science entries) that make the findings in subsequent sections of this report particularly timely and important. This is especially the case in relation to teachers' levels of knowledge, favourability and confidence.

3. Teaching Expertise

The survey of schools and colleges explored teaching expertise for computing education in terms of teachers' understanding of the subject matter, favourability towards the curriculum, and confidence in their own abilities to teach to the levels required. Other aspects covered in this section include the background qualifications and experience of surveyed computing teachers and the amount and nature of computing–related CPD that was undertaken in 2015/16.

3.1 Understanding and Favourability

3.1.1 Understanding of Computational Thinking

Computational Thinking involves taking a complex problem and breaking it down into a series of smaller, more manageable parts (decomposition). Each part can then be looked at individually, considering how similar problems have been solved in the past (pattern recognition), and focusing only on the important details whilst ignoring irrelevant information (abstraction). Next, simple steps or rules to solve each of the smaller problems can be designed (algorithms). Finally, these simple steps or rules are used to program a computer to help solve the complex problem in the best way[17].

The new computing curriculum in England (Key Stages 1 to 4) requires students to understand the principles of computation and analyse problems in computational terms. In Scotland, the revised Curriculum for Excellence – Technologies (refreshed as part of the *2016 Digital learning and teaching Strategy for Scotland)* requires students to understand the world through computational thinking.

Surveyed schools were asked to rate on a scale from 1 'no understanding' to 10 'complete understanding', how well they understood this concept (using the above definition) prior to completing the survey. The results are shown in Figures 2 to 5, comprising.

- Basic histograms showing the distribution of self-reported teacher ratings (Figures 2 and 3);
- Box plots by category of teacher, length of teaching experience and (for secondary schools/colleges only) by nation (Figures 4 and 5)[18].

The observed distribution of ratings among primary teachers is generally mixed, although surveyed secondary teachers show comparatively stronger levels of understanding. Specifically, more than half of primary teachers (52%) gave a rating of 8 or higher, although a quarter (25%) rated their

[17] Source: BBC Bitesize

[18] Base numbers of respondents per category are set out in Appendix A2 and are considerably higher for some compared to others, notably England compared to the devolved nations.

understanding with a score of 5 or lower. This compares to three quarters (75%) of secondary teachers who gave a rating of 8 or higher.

Figure 2 Understanding of computational thinking – primary schools (histogram)

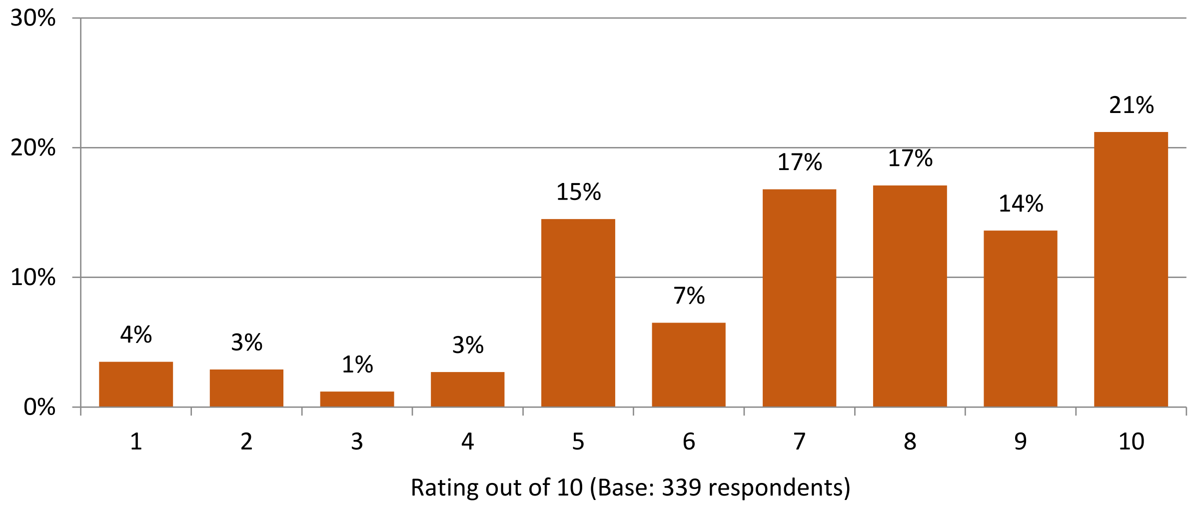
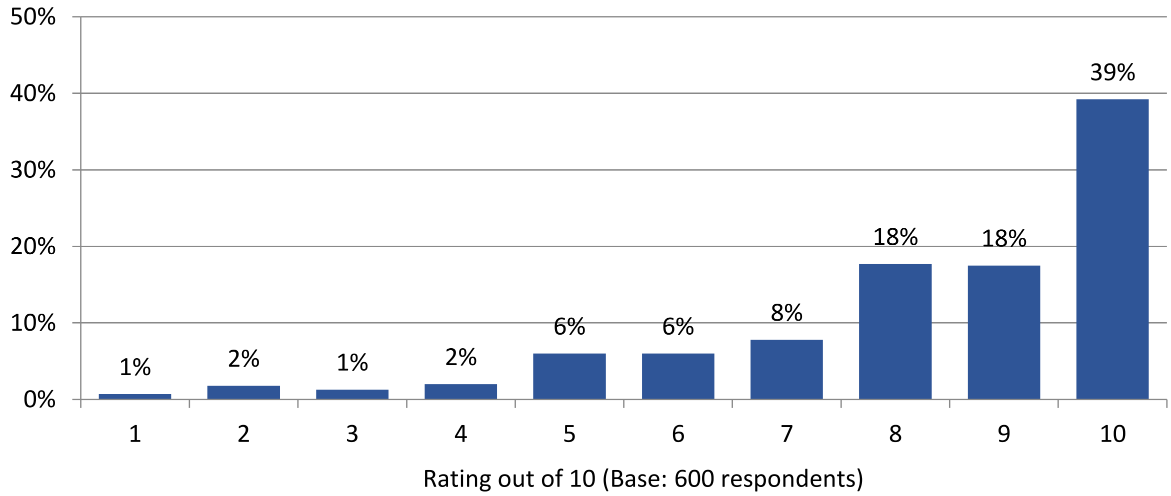


Figure 3 Understanding of computational thinking – secondary schools/colleges (histogram)

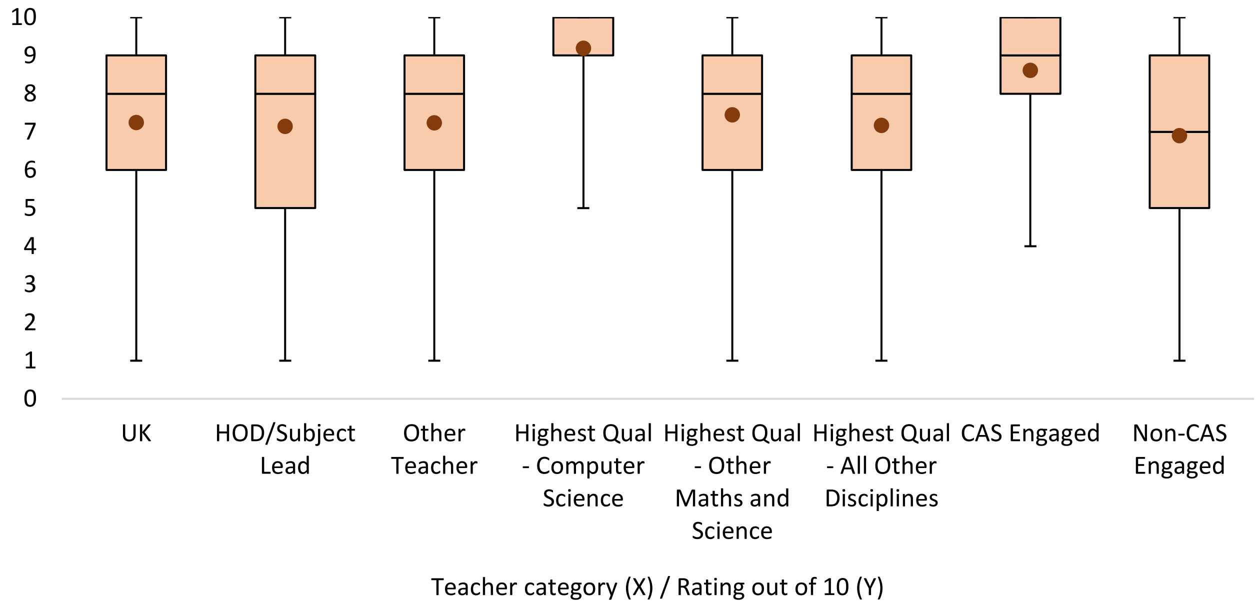


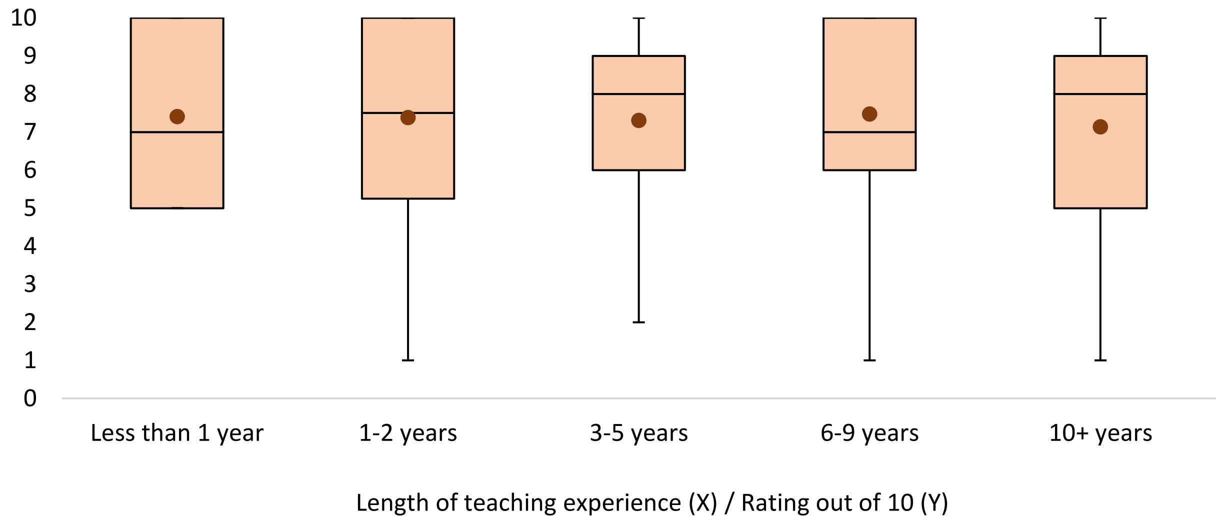
It is important to note that in Scotland, teachers at secondary level are required to be qualified in their chosen subject. Applicants to teaching positions in computing must have a degree with 80 SCQF credit points which has 40 SCQF credit points at SCQF Level 8 (or above) from at least two of: Computer Systems; Software Development; and Databases or Information Systems. The other 40 credits are required in any computing area relevant to the computing curriculum in Scottish schools[19].

[19] Source: The General Teaching Council for Scotland.

Sub-group analysis using box plots[20] reveals that surveyed secondary teachers in Scotland have comparatively stronger levels of understanding than those in the other UK nations. Additionally, primary and secondary teachers who hold their highest qualification in Computer Science have a better understanding of computational thinking than those qualified in another discipline. Statistical testing points to this being a significant finding. There is also evidence of significance that primary teachers who have engaged in CAS-related CPD have a better understanding of computational thinking compared to others[21]. Among secondary teachers, levels of understanding are generally consistent between the nations.

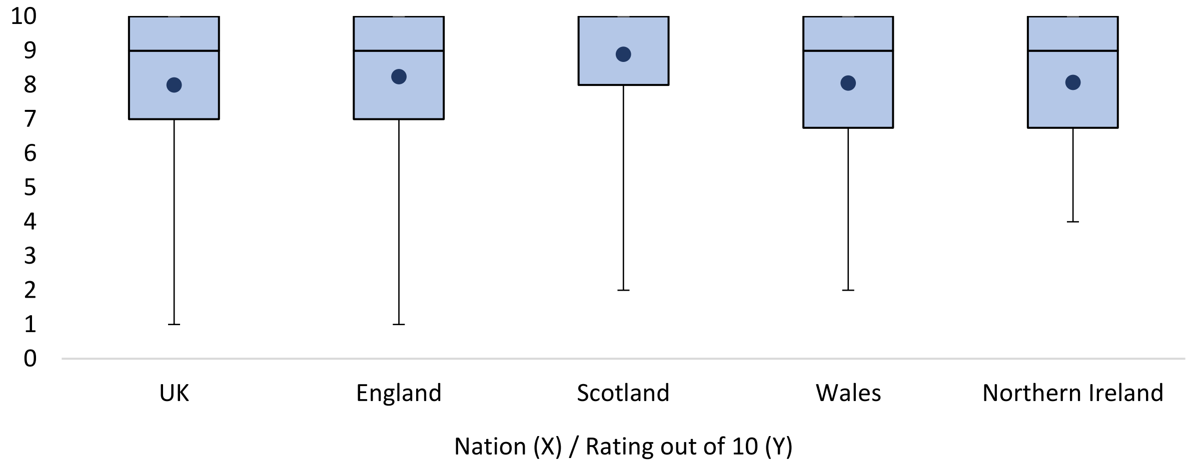
Figure 4 Understanding of computational thinking – primary schools (box plots)

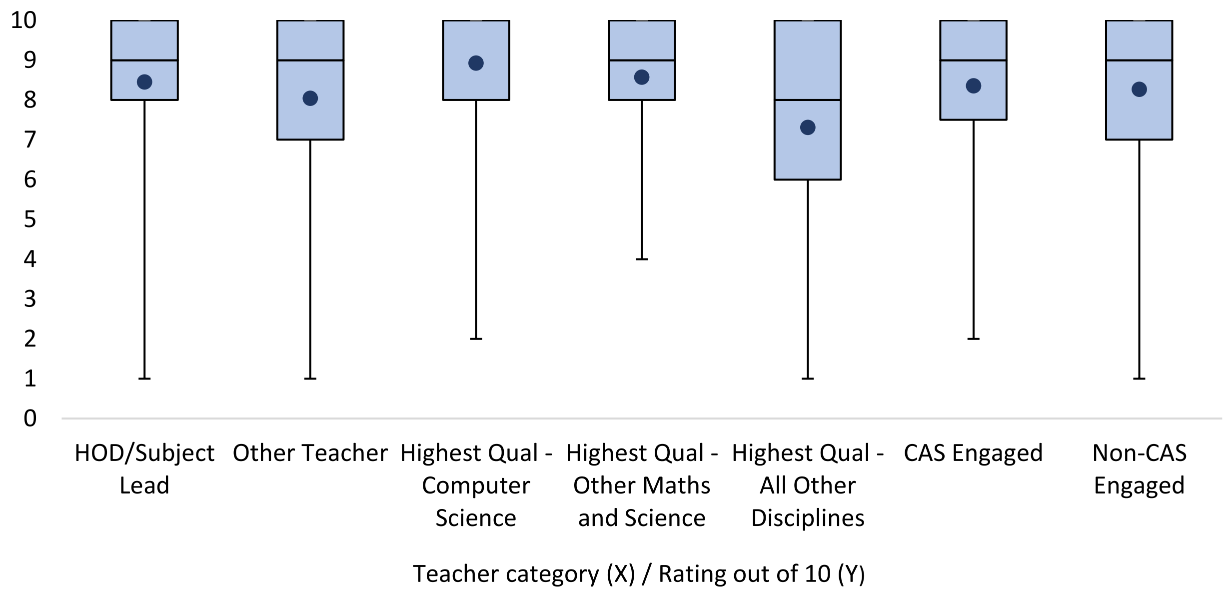


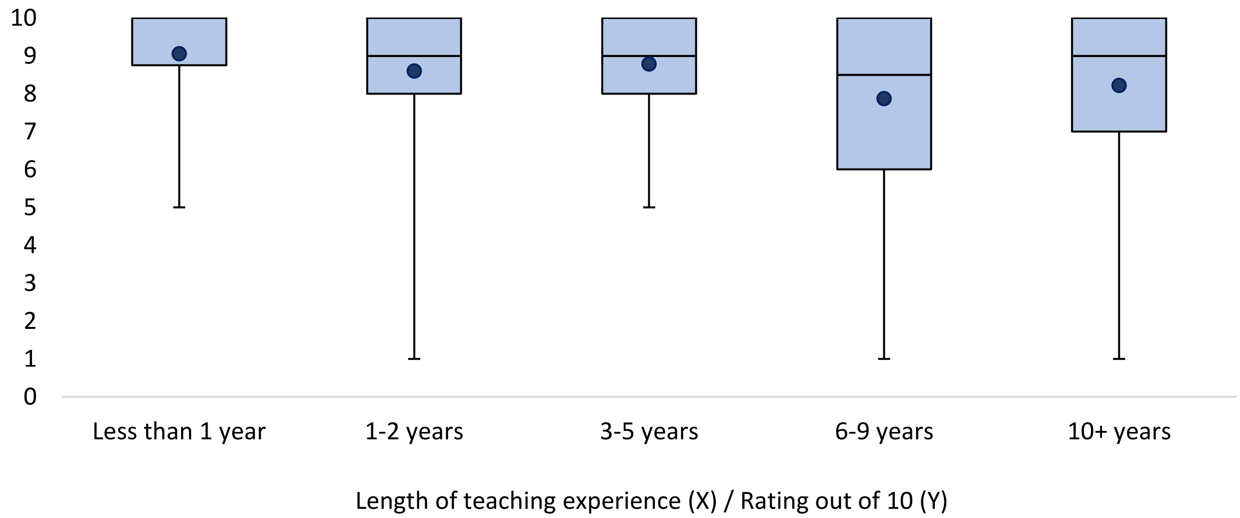


[20] **Key to the box plots:** Mean = coloured spots; 1st Quartile and 3rd Quartile = lower and upper limits of the coloured boxes; Median = horizontal line within the coloured boxes; Range = lower and upper limits of the whisker lines.
[21] See Appendix A5 for details of the statistical tests, the results of which should be used with care.

Figure 5 Understanding of computational thinking – secondary schools/colleges (box plots)







3.1.2 Favourability to the Curriculum

Based on a rating scale from 1 ‘not at all favourable’ to 10 ‘completely favourable’, teacher attitudes towards the new computing curriculum in England are mixed. The observed distribution of ratings given by secondary schools/colleges is more dispersed than primary schools. Specifically, almost two thirds of primary teachers (65%) gave a rating of 8 or higher. This compares with just 38% of secondary teachers. A further 38% of secondary teachers rated their favourability at 5 or below (Figures 6 and 7).

Figure 6 Favourability rating – England primary teachers (histogram)

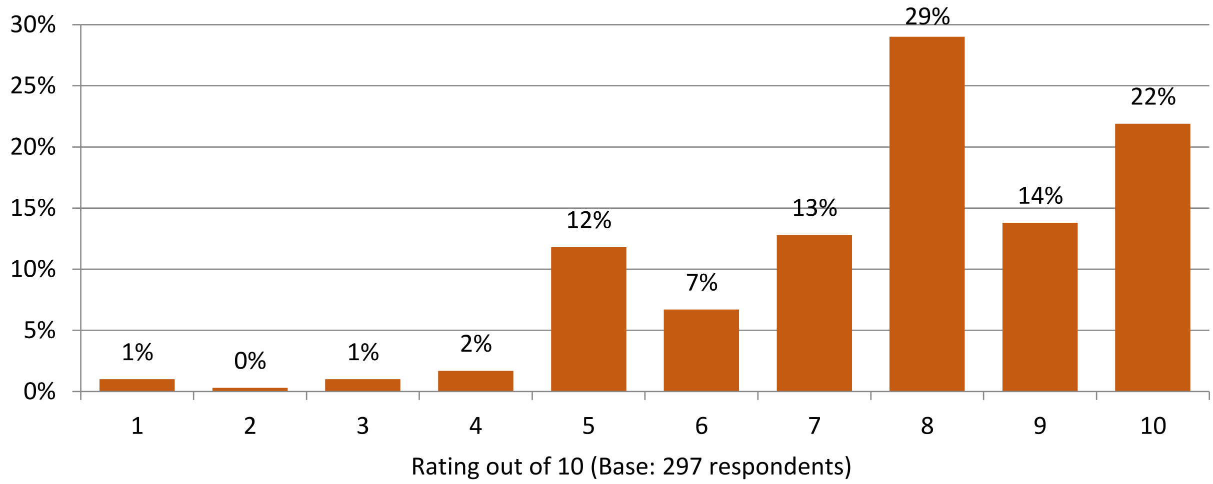
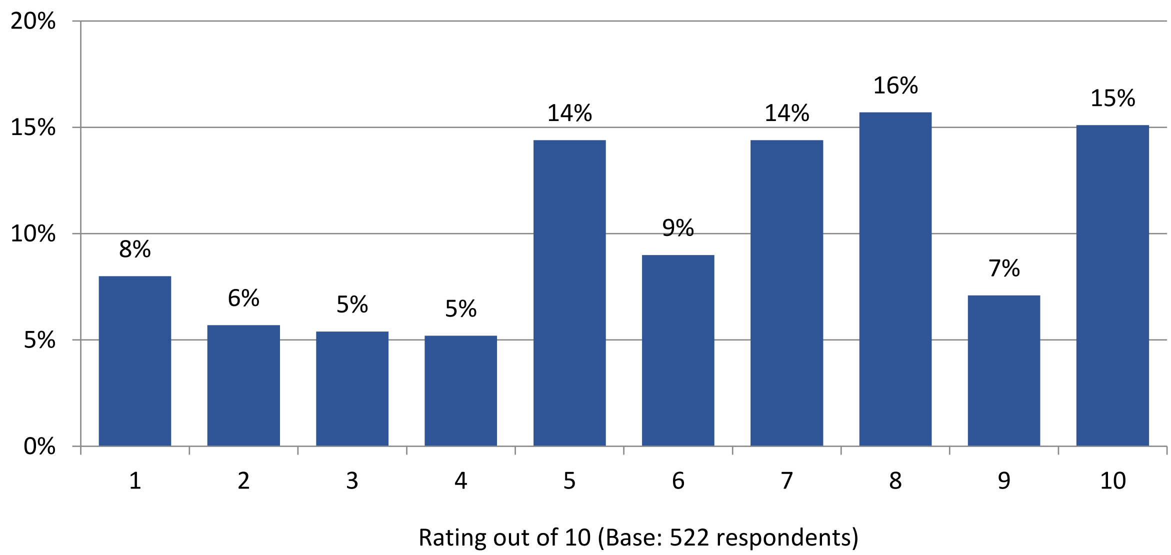


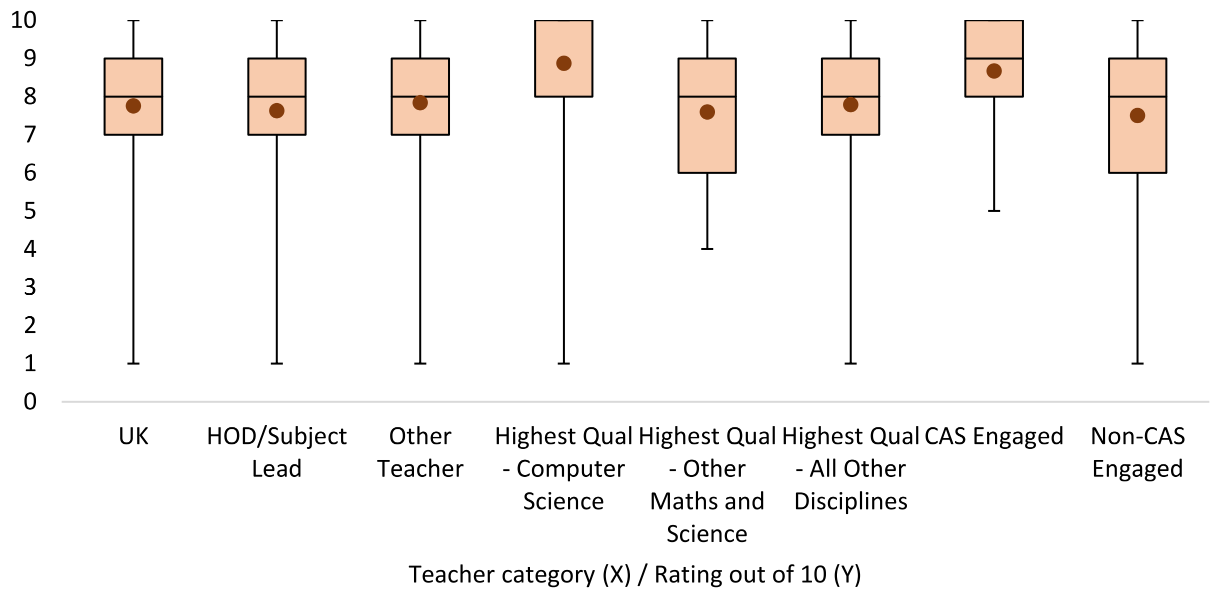
Figure 7 Favourability rating – England secondary schools/colleges (histogram)

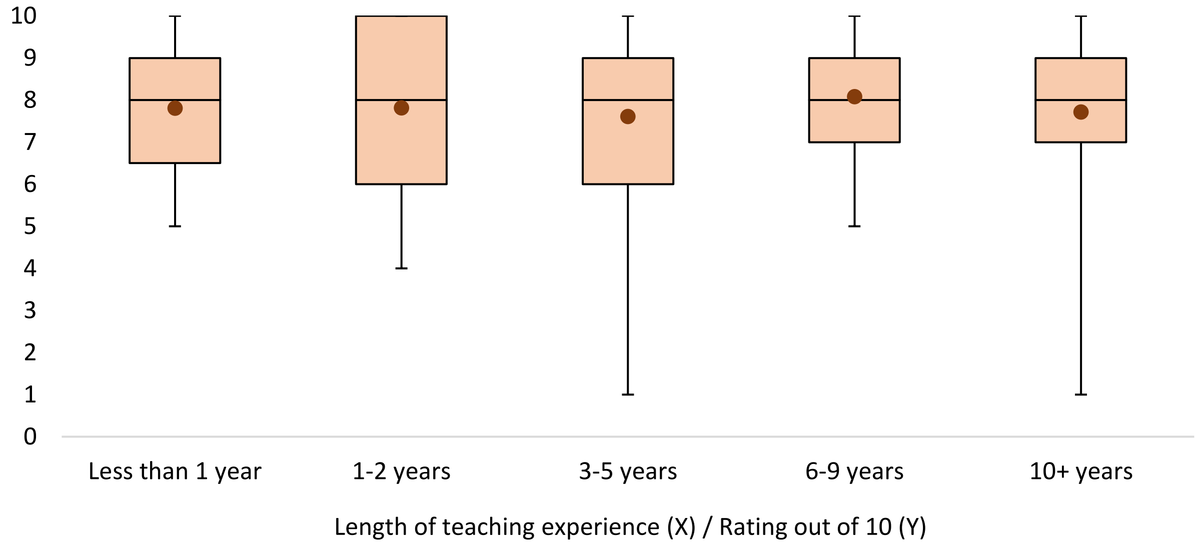


Perhaps unsurprisingly, the box plots show that surveyed primary and secondary teachers who hold their highest qualification in Computer Science are comparatively more favourable than those qualified in a different discipline. This is a statistically significant finding. There is also evidence of significance that primary teachers who have engaged in CAS-related CPD are more favourable than those that have not done so.

In secondary schools/colleges, statistical testing points to surveyed heads of department/subject leads being statistically more favourable than other teachers, while teachers who have been in the profession for less than one year are identified as statistically more favourable than those that have been in the profession beyond three years[22].

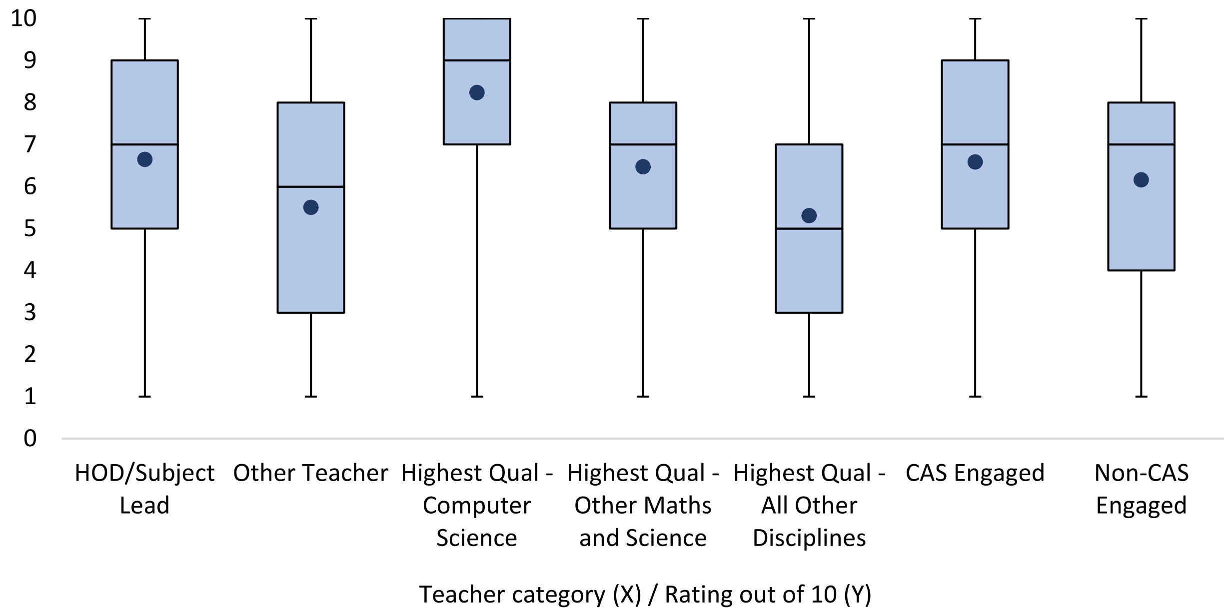
Figure 8 Favourability rating – primary schools (box plots)

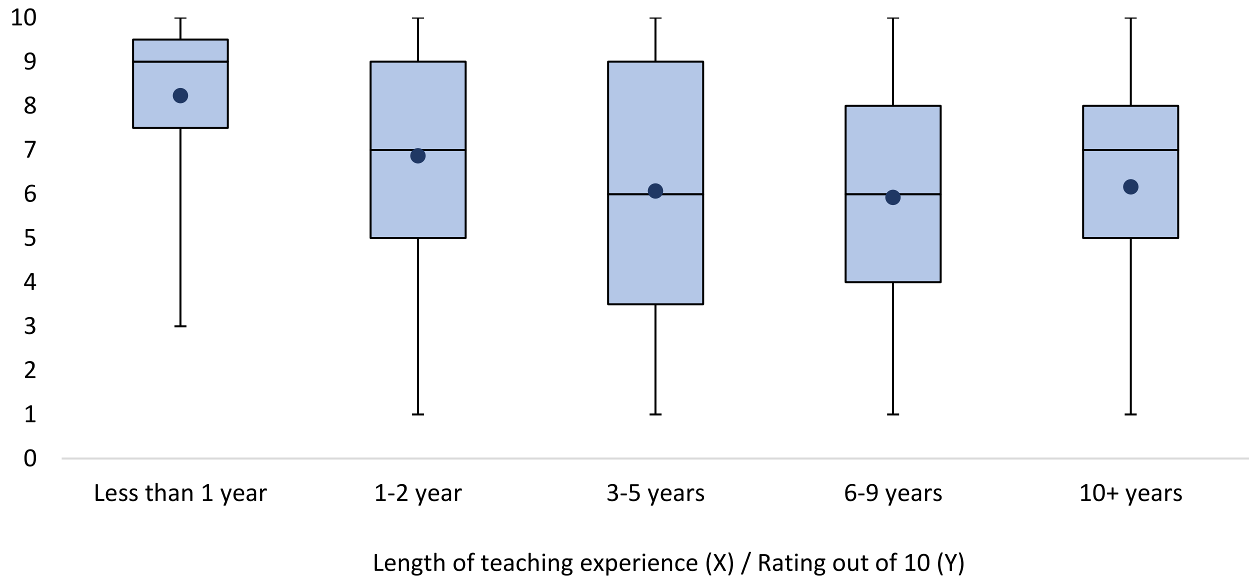




[22] See Appendix A5 for details of the statistical tests, the results of which should be used with care.

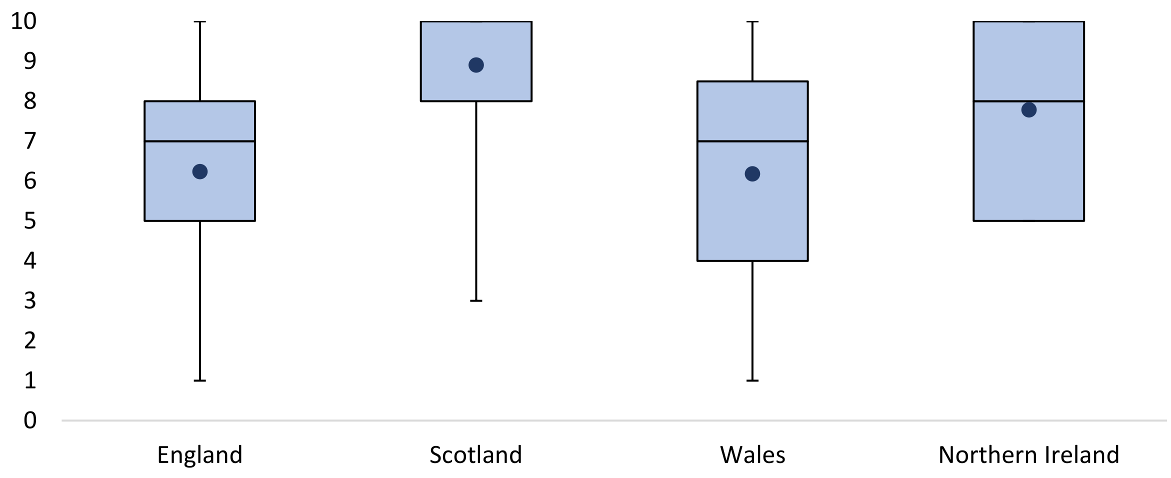
Figure 9 Favourability rating – secondary schools/colleges (box plots)





Secondary teachers in the devolved UK nations rated their favourability towards the approach taken in the new curriculum in England. Teachers in Scotland and Northern Ireland are comparatively more favourable than those in Wales (the latter being on par with England) – Figure 10.

Figure 10 Favourability rating by nation – secondary schools/colleges (box plots)



Perceived strengths of the new curriculum in England:

Teachers providing the highest ratings view computing as “the future” and that programming and coding skills are vital for industry. The accelerating pace of change in robotics and software development is considered strong justification for teaching the knowledge and skills required for the UK to be a strong global leader in the field.

According to these teachers, it is important to teach children to be “creators” of technology rather than simply “users” of office-based ICT products. Thinking computationally is viewed as a skill that has cross-curricular benefits for a range of other subjects (not only maths and science), and is relevant to life and work.

Secondary school teachers most strongly in favour of the new curriculum describe traditional ICT as “vague”, “boring” and “monotonous”, with computing by comparison seen as “creative”, “challenging”, “interesting” and “important”. Computing is viewed by these teachers as being more relevant than ICT, not only for industry and society, but to provide a better foundation for further and higher education courses in computer science or a related discipline.

At the Newcastle discussion group, participants described how the new curriculum teaches young people how to think and problem solve using logic and algorithms from an early age in primary schools. It was argued that the curriculum has been “liberating”, allowing for a great deal of creative freedom.

The pace of change in computing was discussed at the Manchester discussion group as having positive and negative benefits, for example while the subject is fresh, contemporary and relevant to the modern world, ever-changing technologies mean that teachers can be “pulled in different directions” with a risk that schools’ investment in equipment and software will inevitably have a limited shelf life.

Several participants in the discussion groups and case studies emphasised the importance of teachers and pupils "learning together", which they feel makes the subject unique in that respect. Where there are students in secondary schools with a strong outside interest in the subject (in one case study school, two A level students were involved in developing their own mobile apps) this presents opportunities for those students to help in various ways, such as running lunchtime clubs or supporting younger year groups. This two-way learning approach was described as invaluable for teachers, especially non-specialists, in overcoming the "fear factor" associated with computing. The challenge here, as mentioned in the Cardiff discussion group, is when teachers feel intimidated by students for being less tech-savvy, as this can have a knock-on effect on teacher confidence.

"Computer science is a rigorous academic discipline and underpins the majority of today's science and technology (and more)… The skills developed are critical to almost all senior management roles and across all business sectors."

Head of Computing, Secondary school

Perceived issues associated with the new curriculum in England:

Not all teachers share the same enthusiasm for the subject and there is anecdotal evidence from the discussion group discussions that some schools are not implementing the subject. A notable concern, particularly among some secondary schools (in which surveyed teachers are comparatively less favourable than those of primary schools), is that the balance in the new curriculum is weighted too heavily towards computer science and that vital and fundamental ICT skills risk being side-lined.

With the growing use of tablets and other touch-screen technology, there is a worry that children are losing important basic skills such as using a mouse, keyboard, manually saving documents in folders, working with spreadsheets and delivering effective presentations. Participants argued strongly in the Birmingham discussion group that such skills are important for more jobs than those requiring programming and coding skills, and that it must not be assumed that young people learn these tasks by themselves. Teachers generally in favour of the new computing curriculum also emphasised strongly that ICT must not be eclipsed, making the point that a balance needs to be maintained between digital literacy, ICT and computer science.

Primary school teachers unfavourable to the new curriculum described the requirements as being too advanced for the available physical resources and budget, that staff lack the required skill-set and knowledge to teach the subject, and that the language used in the curriculum is overly-technical.

"Far too much is expected of children in terms of their understanding of all things technology related. We should be focusing on making sure they can read, write and use maths confidently, before trying to teach them coding."

Computing teacher, Primary School

A small number of teachers made the point in response to the survey and during discussion groups that the new curriculum appears to have been implemented without due regard to who would teach it and how it would be taught. One secondary teacher described computer science as having been "parachuted in" and that it was rather assumed ICT teacher would be able to adapt or migrate to this subject without appreciating how different the two subjects are in reality.

3.1.3 Defining Teacher Profiles

By cross-tabulating how teachers rated their 'understanding of computational thinking' (using the definition in section 3.1.1) against their 'favourability towards the computing curriculum', it is possible to develop a set of four teacher profiles.

Firstly, the cross-tabulations and numbers of respondents providing ratings in response to both of these questions are shown in Table 5 (primary) and Table 6 (secondary). With respect to secondary schools/colleges in particular, it is clear that for the least knowledgeable teachers there is an upper limit on their affection for the curriculum, and this ceiling rises with teacher confidence. The floor on favourability remains steadily low, with some of the most knowledgeable teachers giving the new curriculum the lowest possible ratings.

The four coloured quadrants in Tables 5 and 6 are used as a basis for defining teacher profiles – explained further below.

Table 5 Understanding and favourability (primary schools in England)

	Understanding of computational thinking											
Favourability to the curriculum	**Rating**	**Base**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Base	297	6	7	4	6	40	21	51	52	43	67
	1	3	-	-	-	-	1	-	-	-	-	2
	2	1	-	-	-	-	-	1	-	-	-	-
	3	3	-	-	-	2	1	-	-	-	-	-
	4	5	1	2	-	-	1	1	-	-	-	-
	5	35	2	3	1	1	12	2	6	5	1	2
	6	20	-	-	-	-	9	3	1	7	-	-
	7	38	1	1	1	-	7	3	8	7	5	5
	8	86	1	-	-	1	6	7	18	18	11	24
	9	41	-	-	1	1	2	3	11	7	11	5
	10	65	1	1	1	1	1	1	7	8	15	29

Table 6 Understanding and favourability (secondary schools/colleges in England)

Favourability to the curriculum	Understanding of computational thinking											
	Rating	**Base**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Base	522	4	9	7	10	34	32	39	98	93	196
	1	42	2	2	3	1	6	2	5	7	1	13
	2	30	-	5	-	2	1	5	1	7	3	6
	3	28	1	-	2	1	6	1	3	4	1	9
	4	27	-	1	1	2	2	2	2	4	3	10
	5	75	1	-	-	1	8	10	5	14	16	20
	6	47	-	1	1	-	-	3	7	13	6	16
	7	75	-	-	-	2	3	4	8	20	13	25
	8	82	-	-	-	1	3	2	5	17	13	41
	9	37	-	-	-	-	2	2	3	2	22	6
	10	79	-	-	-	-	3	1	-	10	15	50

An explanation of how the coloured quadrants form teacher profiles is set out in Table 7. These archetypal groups are used from this point forward to compare levels of teacher confidence, CPD activities, and use of teaching support.

The profiles should not be considered completely rigid, nor do the groups necessarily have clear boundaries in reality. They are intended purely as framework for defining broad typologies of teachers in the context of computing education. For example in the ‘advocates group’ (green), those respondents providing ratings of 10 out of 10 to both questions (bottom right corner of Tables 5 and 6) may be considered stronger ‘advocates’ than those providing ratings of 7 or 8 out of 10. Similarly those providing ratings of 1 or 2 out of 10 for both questions (top left corner of tables 5 and 6) may be considered ‘less engaged’ than those providing ratings closer to the centre of the scale.

Table 7 Teacher profiles – definitions

Quadrant	Defining characteristics	England respondents	
		Primary	Secondary
Advocates profile: Strong understanding of computational thinking and high favourability towards the computing curriculum.	Rating of understanding of computational thinking: At least 7 out of 10. Rating of favourability to the new computing curriculum: At least 7 out of 10.	189	250
Supporters profile: Comparatively less understanding of computational thinking but high favourability towards the computing curriculum.	Rating of understanding of computational thinking: Less than 7 out of 10. Rating of favourability to the new computing curriculum: At least 7 out of 10.	41	23
Critics profile: Strong understanding of computational thinking but comparatively low favourability towards the computing curriculum.	Rating of understanding of computational thinking: At least 7 out of 10. Rating of favourability to the new computing curriculum: Less than 7 out of 10.	24	176
Less Engaged profile: Comparatively less understanding of computational thinking and comparatively low favourability towards the computing curriculum.	Rating of understanding of computational thinking: Less than 7 out of 10. Rating of favourability to the new computing curriculum: Less than 7 out of 10.	43	73

3.1.4 Digital Competence Framework – Wales

In Wales from September 2016, a new Digital Competence Framework[23] was made available for schools, placing responsibility on all teachers and practitioners to embed digital competence in lessons.

On a scale from 1 to 10, surveyed schools in Wales were asked to rate their preparedness for the new framework. Responses from 18 secondary schools in Wales resulted in an average rating of 6.8 out of 10, while the average rating from four responding primary schools was 3.8 out of 10. These findings should be treated with extreme caution given the low base number of responses.

[23] Digital competence enables a person to be a confident digital citizen, to interact and collaborate digitally, to produce work digitally and to be confident in handling data and computational thinking (problem solving). Digital competence is distinct from ICT but they the two are interrelated (particularly in primary education).

While primary schools did not provide supporting reasons, secondary respondents described being generally confident in their underpinning knowledge to embed digital literacy, or mentioned actively looking into how this could be applied within their school. It was argued that the framework's success will ultimately depend on the effectiveness of 'top down' implementation and training for staff

One participant at the Cardiff discussion group mentioned "we're a non-digital generation" and described how aspects of computer science could be quite a leap for some teachers. A counter-argument was that the new framework is rightfully aspirational and that it would be "unacceptable" if teachers are not equipped to deliver it, thereby emphasising the importance of a clear strand of CPD in this area.

3.1.5 Curriculum for Excellence – Scotland

In Scotland, the proposed changes to the Curriculum for Excellence generally appear to be well received, with discussion group and case study participants welcoming the clearer distinction between the topics of computer science and digital literacy. They are also favourable to the framework's use of 'experience' and 'outcome' measures, which are viewed as a clear way of benchmarking progress and helping students to decide if the subject would be the right choice for them.

One respondent expressed some concern about the introduction of new foundation skills, which they feel would be beyond most primary schools due to lack of technology and insufficient staff expertise.

3.1.6 Entitlement Framework – Northern Ireland

The entitlement framework in Northern Ireland refers to the post 14 curriculum which aims to provide access for students to a broad and balanced curriculum to enable them to reach their full potential. Discussion group participants in Belfast described how this has stimulated their decision to offer Computer Science qualifications in their schools from England-based awarding organisations as a fresh, forward-looking and strong academic subject. These participants praised the changes taking place in England and feel strongly that Northern Ireland should follow suit.

3.2 Confidence

3.2.1 General Confidence in delivering Computing Education

On a scale from 1 'not at all confident' to 10 'completely confident', teachers were asked to rate their own confidence in delivering the curriculum at each distinct Key Stage/level.

Observed levels of confidence are lower among surveyed secondary schools than primary schools, and there is a drop in the mean confidence rating across each successive level of secondary education, from 8.5 at Key Stage 3, down to 6.6 at A level/equivalent (Figures 11 to 15 and Tables 8 and 9).

For both primary and secondary schools/colleges, there is evidence of statistical significance that teachers holding their highest qualification in Computer Science are more confident than those qualified in other disciplines. In secondary schools/colleges, the difference in ratings given by heads of department/computing subject leads and other teachers is also significant[24].

Figure 11 Confidence – primary schools (means)

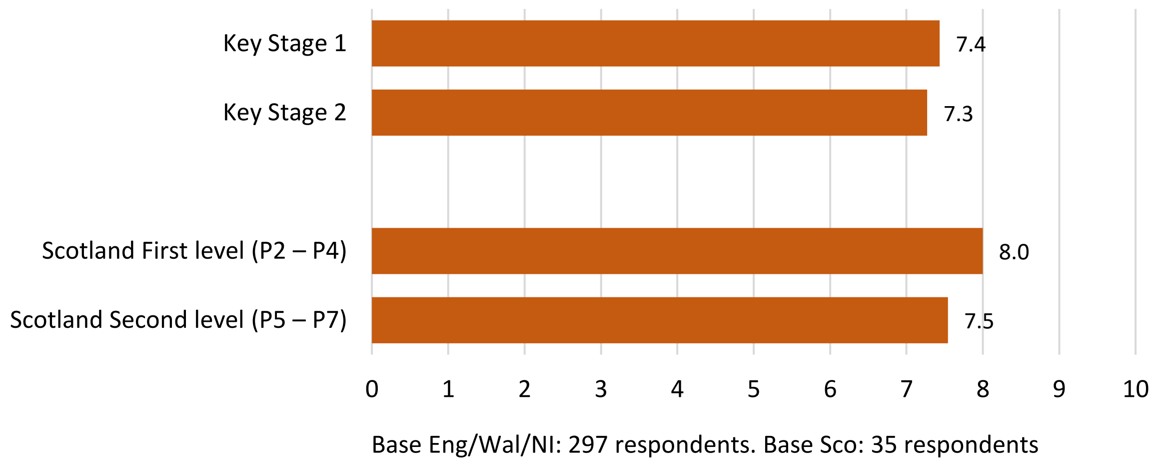
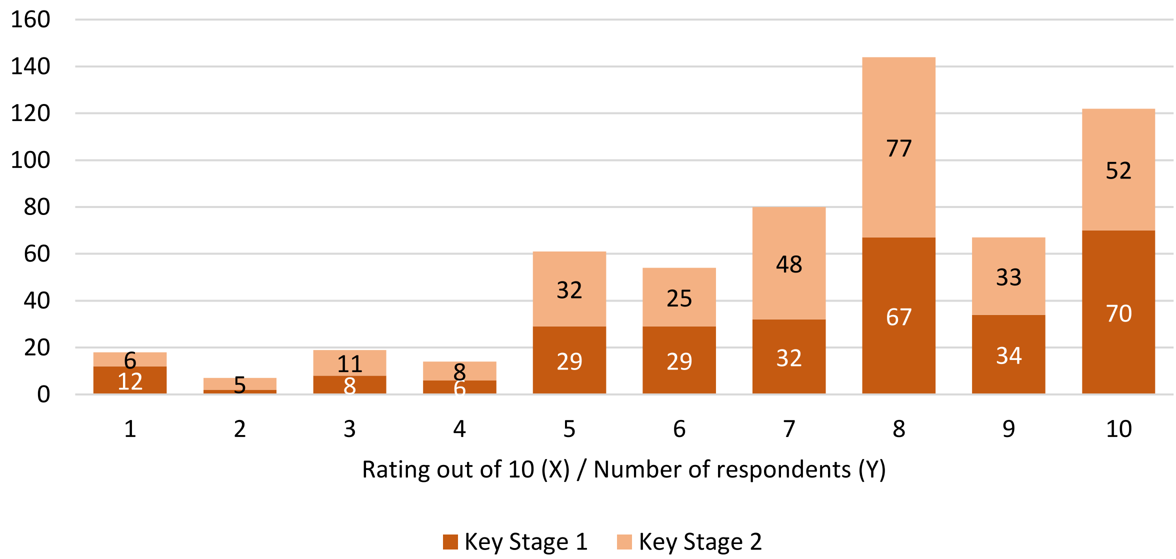


Figure 12 Confidence – primary schools (rating distribution)



[24] See Appendix A5 for details of the statistical tests, the results of which should be used with care.

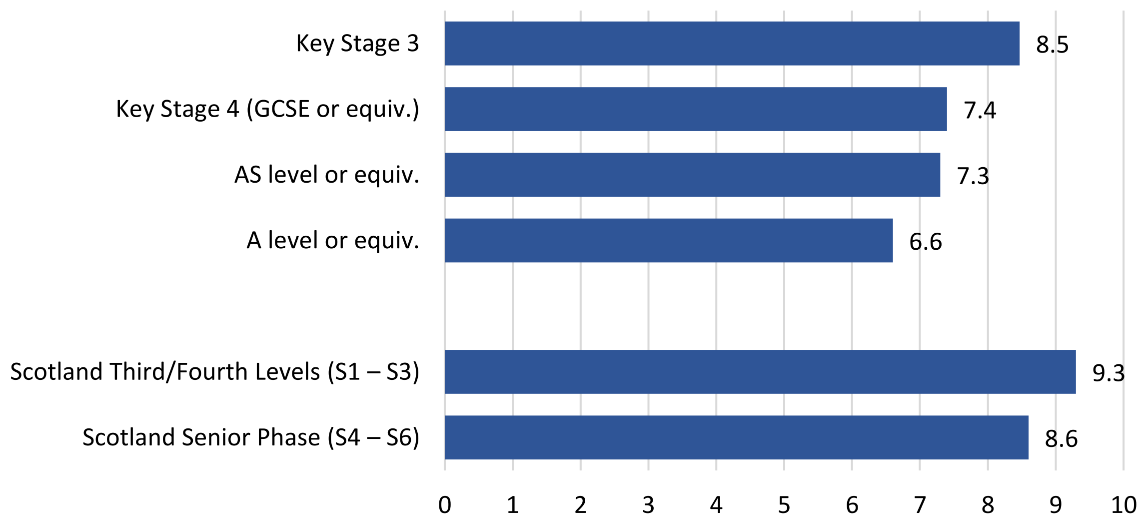
Table 8 Confidence – primary schools (by respondent category)

Key Stage/ Level	All	CAS Engaged	Non-CAS Engaged	Head/ Subject Lead for Computing	Other Teachers	Highest Qual - Computer Science	Highest Qual - Other Maths and Science	Highest Qual - All Other Disciplines
Key Stage 1	7.4	8.1	7.3	7.4	7.4	8.7	8.0	7.3
Key Stage 2	7.3	8.2	7.0	7.3	7.3	9.3	7.3	7.2
Scotland P2 – P4	8.0	8.8	7.9	8.0	7.9	8.8	9	7.8
Scotland P5 – P7	7.5	8.3	7.5	7.3	7.6	8.9	8.3	7.5

For England, analysis of surveyed primary teachers by each of the four teacher profiles (cf. section 3.1.3) reveals that Advocates are the most confident in delivering the curriculum, and the Less Engaged group of teachers are the least confident. It is perhaps unsurprising that Critics are more confident than Supporters, since this group has comparatively stronger understanding of computational thinking than the Supporters, however they are comparatively less favourable to the curriculum.

Key Stage/ Level	Group 1 – Advocates	Group 2 – Supporters	Group 3 – Critics	Group 4 – Less Engaged
Key Stage 1	8.0	6.9	7.3	5.6
Key Stage 2	8.2	6.3	7.0	4.7

Figure 13 Confidence – secondary schools/colleges (means)[25]



Base Eng/Wal/NI: 537 respondents. Base Sco: 46 respondents

[25] These average ratings have been filtered to only include teachers who stated that they currently teach at each respective level.

Figure 14 Confidence – secondary schools/colleges in England/Wales/NI (rating distribution)

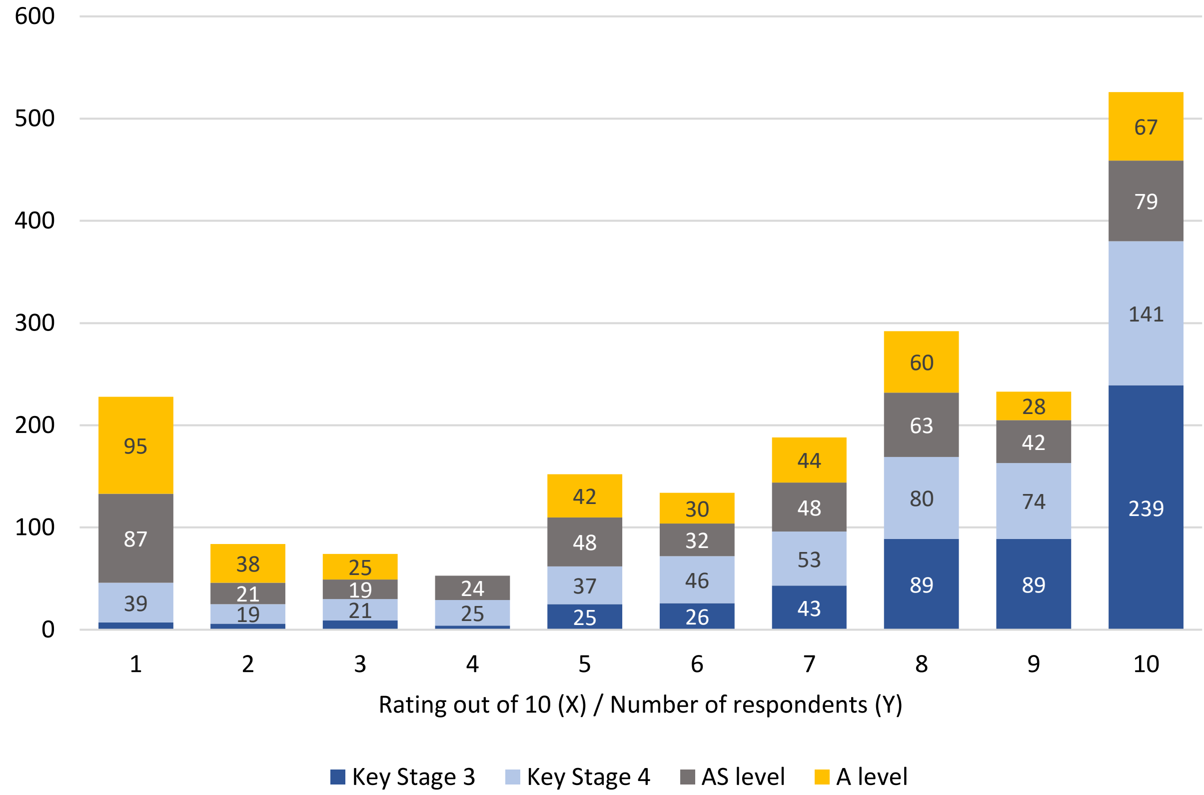


Figure 15 Confidence – secondary schools/colleges in Scotland (rating distribution)

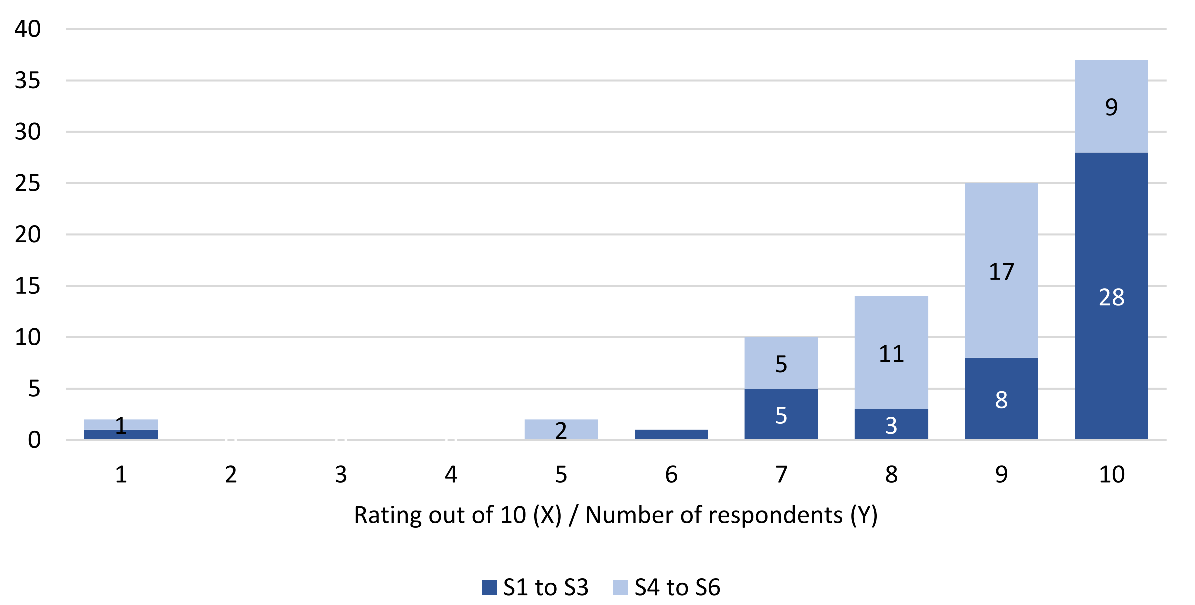


Table 9 Confidence – secondary schools/colleges (by respondent category)

Key Stage/ Level	All	CAS Engaged	Non-CAS Engaged	HoD/ Subject Lead for Computing	Other Teachers	Highest Qual - Computer Science	Highest Qual - Other Maths and Science	Highest Qual - All Other Disciplines
Key Stage 3	**8.5**	8.9	8.5	8.7	8.3	9.1	8.3	8.3
Key Stage 4	**7.4**	7.7	7.3	7.9	6.4	8.1	7.1	7.1
AS level or equivalent	**7.3**	7.2	7.3	7.4	7.2	7.7	7.2	6.9
A level or equivalent	**6.6**	6.6	6.6	6.9	6.1	7.1	6.4	6.2
Scotland S1 – S3	**9.3**	10.0	9.2	9.0	9.5	9.3	9.3	9.4
Scotland S4 – S6	**8.6**	9.0	8.6	8.5	8.7	8.6	8.5	8.9

For England, analysis of surveyed secondary/college teachers by each of the four teacher profiles (cf. section 3.1.3) reveals a similar pattern in terms of confidence to primary schools. Advocates are the most confident in delivering the curriculum, the Less Engaged group of teachers are the least confident, with Critics and Supporters falling in the middle.

Key Stage/ Level	Group 1 – Advocates	Group 2 – Supporters	Group 3 – Critics	Group 4 – Less Engaged
Key Stage 3	9.1	7.8	8.5	6.6
Key Stage 4	8.7	5.8	6.0	4.3
AS level or equivalent	7.4	3.5	5.0	2.8
A level or equivalent	6.9	3.3	4.2	2.7

Those teachers providing a rating of 6 or below were asked to explain their reasons. Many of these teachers feel that they lack sufficient theoretical and technical knowledge of computing (including aspects of programming and coding). Heads of department/subject leads in primary and secondary schools tended to express these concerns with respect to other teaching staff in their school who also have responsibility for delivering the subject.

In primary schools this issue is exacerbated by competing subject demands, whilst secondary teachers feel that the size of the skills gaps between teaching ICT and teaching computer science "has been underestimated". Some teachers remarked in the survey that there isn't enough training to teach the subject and that they don't have enough time in the working day for computing-related CPD.

A number of unique challenges face computing in the early years of secondary school (Key Stage 3 in England and Wales). Firstly there is the impact of time-tabling, with computing having to compete with a variety of other subjects, often with non-specialist teachers stepping in at this level. Secondly, discussion group and case study participants described how some students can enter Year 7 having had a good grounding in computing at primary school, but their interest and enthusiasm can be easily undone if the secondary school doesn’t have effective teachers and adequate infrastructure. In another scenario, several other participants described how the knowledge and capability of students starting secondary school can be highly variable, reflecting disparities in computing education across feeder primary schools. Teaching computing can therefore be more difficult at this level where students have such different starting points.

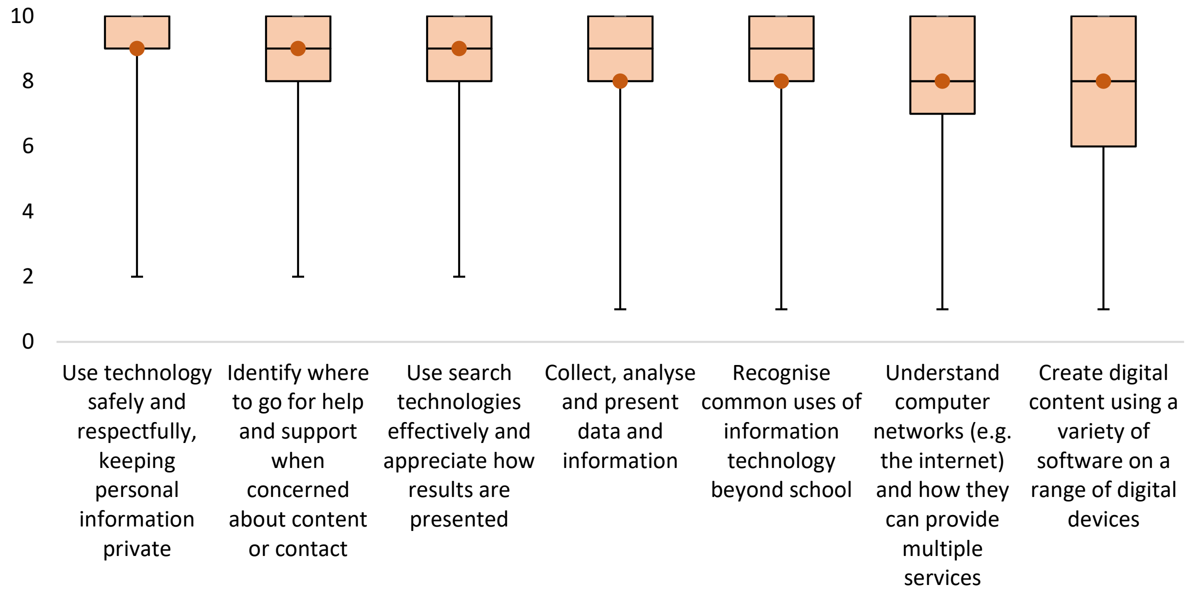
“The discipline is completely new to me. It's like a linguist having to teach a different language but with no resources or preparation time.”

Head of ICT and Computer Science, Secondary School

3.2.2 Confidence in delivering specific aspects of Computing Education

Figures 16 and 17 rank specific aspects of computing education for which schools are most to least confident. The top three highest rated aspects mainly relate to safety and the use (rather than programming) of technology. Less confident areas among primary schools include debugging, working with various forms of input and output, and working with variables. For secondary schools, less confident areas include designing and developing modular programs, as well as using sequence, selection and iteration in two programming languages.

Figure 16 Confidence in specific aspects of the curriculum – primary schools



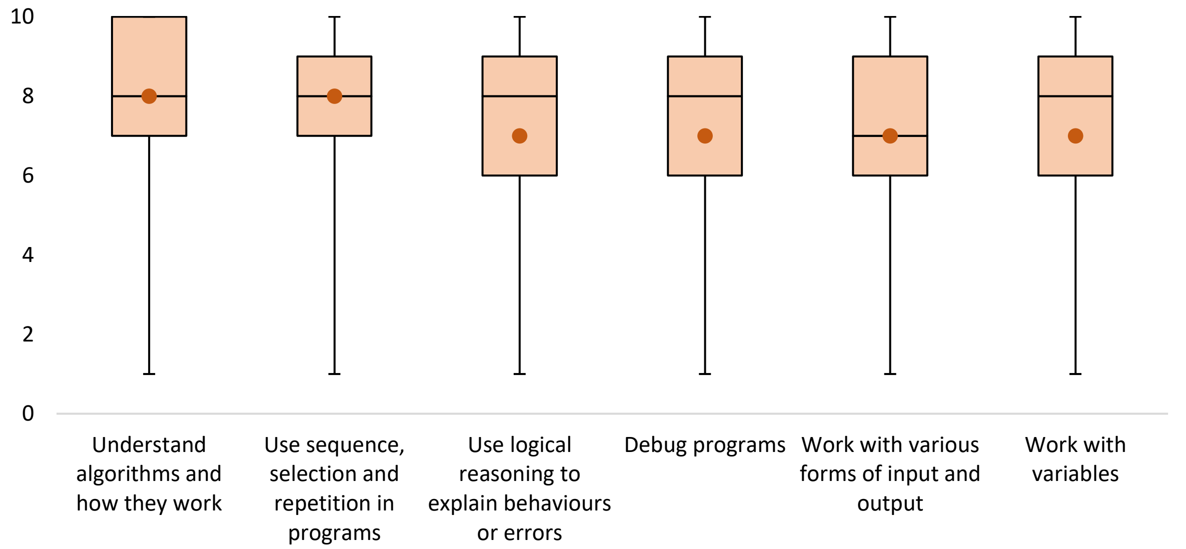
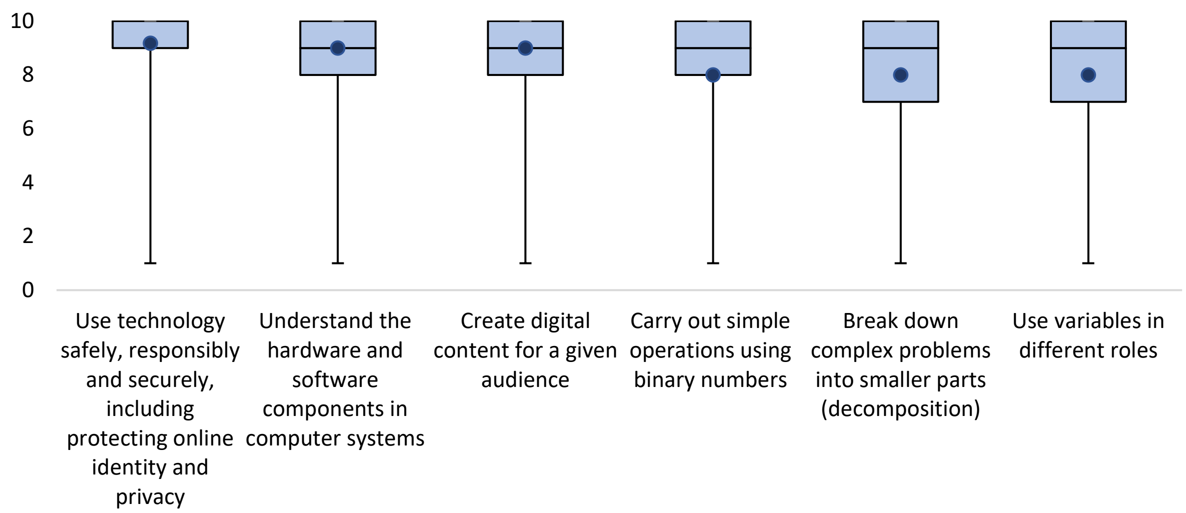
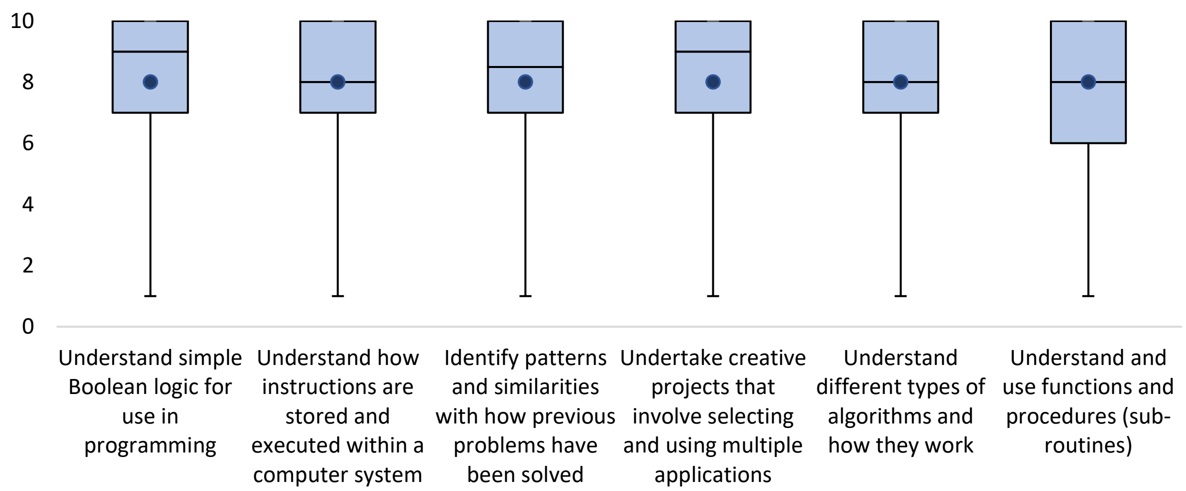
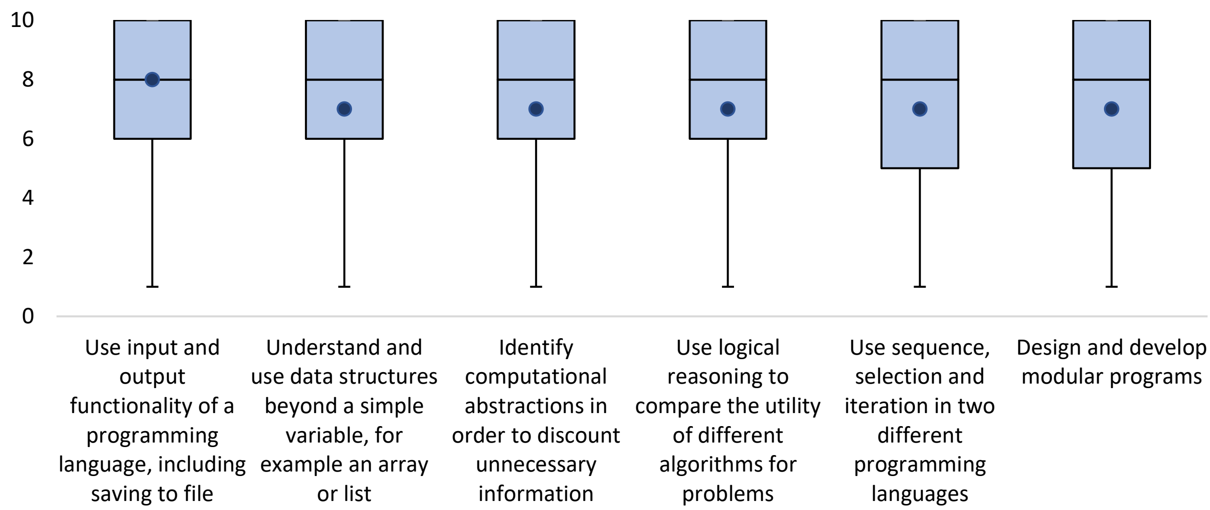


Figure 17 Confidence in in specific aspects of the curriculum – secondary schools/colleges







3.2.3 Improving Confidence in the Future

Surveyed teachers were asked what, if anything, would help to improve their confidence in teaching computing. The most common request among primary and secondary schools was for more training.

Specific suggestions include more courses and other forms of guidance so that teachers can:

- Improve their subject knowledge and understanding (including comprehensive technical training and greater exposure to programming and coding);
- Explore how to make the most of opportunities in the computing curriculum, including sharing practical ideas for delivering engaging lessons, best practice and proven methods for teaching programming;
- Better understand the performance benchmarks for GCSE/A level computing qualifications, including how these map to grades so that students can be better informed about their grade potential;
- Identify how to get the most out of different student ability groups in the same class; and
- Be able to teach complex theory, particularly at A level.

Teachers desire more CPD opportunities, in particular the time to read around the subject and practise their programming and coding skills, develop pedagogical approaches and assessment materials, design lesson plans and Schemes of Work. In addition, they would welcome more collaboration opportunities to help improve knowledge, for example with subject specialists, industry experts and computer science graduates. Many teachers are also calling for more access to free and high quality teaching and assessment resources and better equipment.

Several secondary teachers mentioned that greater consistency is needed between awarding organisations. Linked to this, a respondent in the Cardiff discussion group discussed in the context of project work how one exam board places greater focus on running and testing a finished product, whist another favours a portfolio-style assessment with screen prints, which are arguably “easier to bluff”.

3.3 Qualifications, Experience and CPD

3.3.1 Qualifications

For England, the Department for Education publishes data on the percentage of secondary school teachers holding their highest level qualification in a relevant subject to the one they teach. The list of subjects (as at November 2015) does not specifically reference 'computer science' but data are provided below for subjects closely linked to computing:

- Combined/General Science: 78% qualified in a related subject;
- Other Sciences: 74% qualified in a related subject;
- Business/Economics: 64% qualified in a related subject;
- Mathematics: 45% qualified in a related subject;
- ICT: 29% qualified in a related subject[26].

Data from the survey of schools and colleges provides more detail about the qualifications of teachers with at least some responsibility for computing education at both primary and secondary levels.

The vast majority of surveyed teachers are qualified at least to Batchelor's Degree level or equivalent in any subject (94% in primary and 98% in secondary schools/colleges). Just under half hold a qualification beyond a Batchelor's degree, with 2% of secondary teachers holding a doctoral qualification.

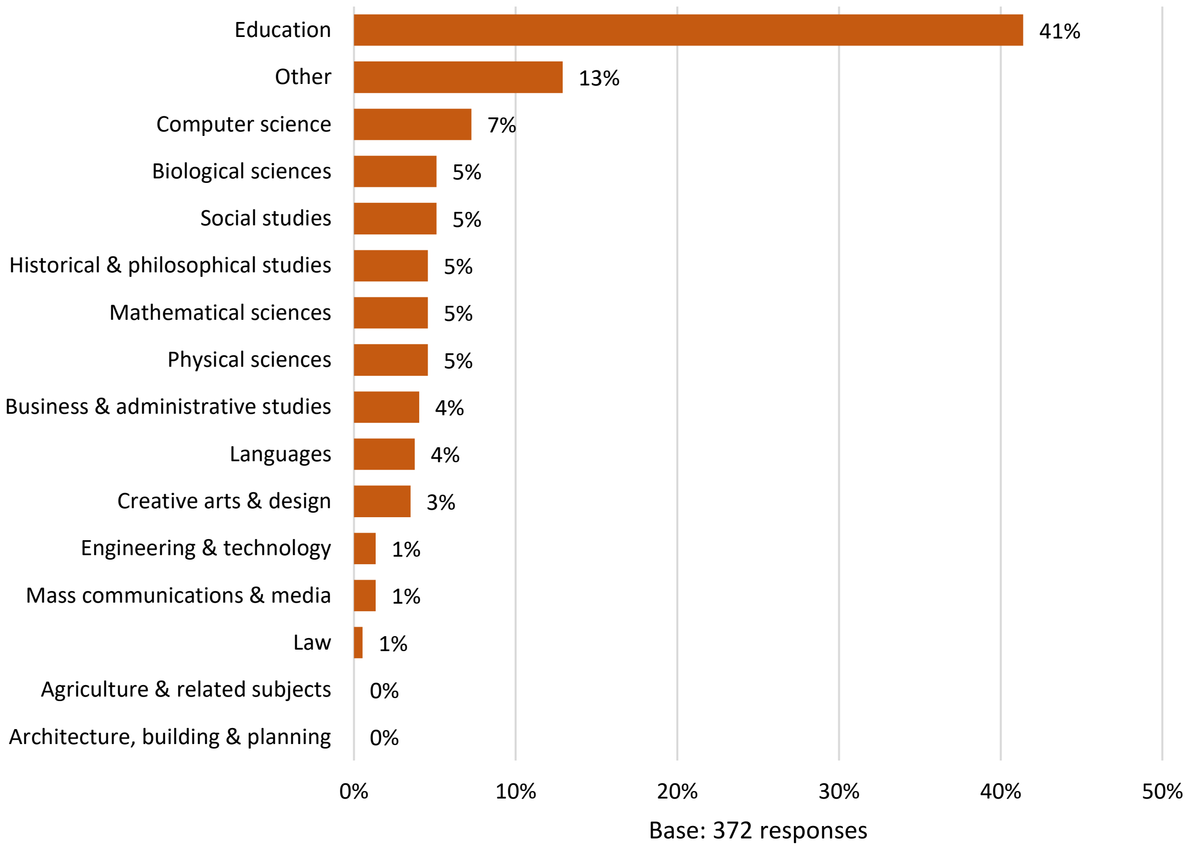
Teachers were asked in which discipline(s) they hold their highest level qualification. As teachers could select more than one answer, the results show the percentage share of total responses, i.e. from most to least mentioned.

The most commonly cited highest qualification held by primary computing teachers is 'Education' (typically referring to their PGCE) which takes a 41% share of responses. However, teachers are generally qualified in a range of disciplines, be it STEM, humanities or arts-related (Figure 18)[27].

[26] Department for Education (June 2016) *School Workforce in England – November 2016*

[27] Highest level qualifications classified by primary school respondents as 'Other' included Archaeology, Childhood Studies/Early Years, English, Geography, Music, Politics, Psychology and Theology.

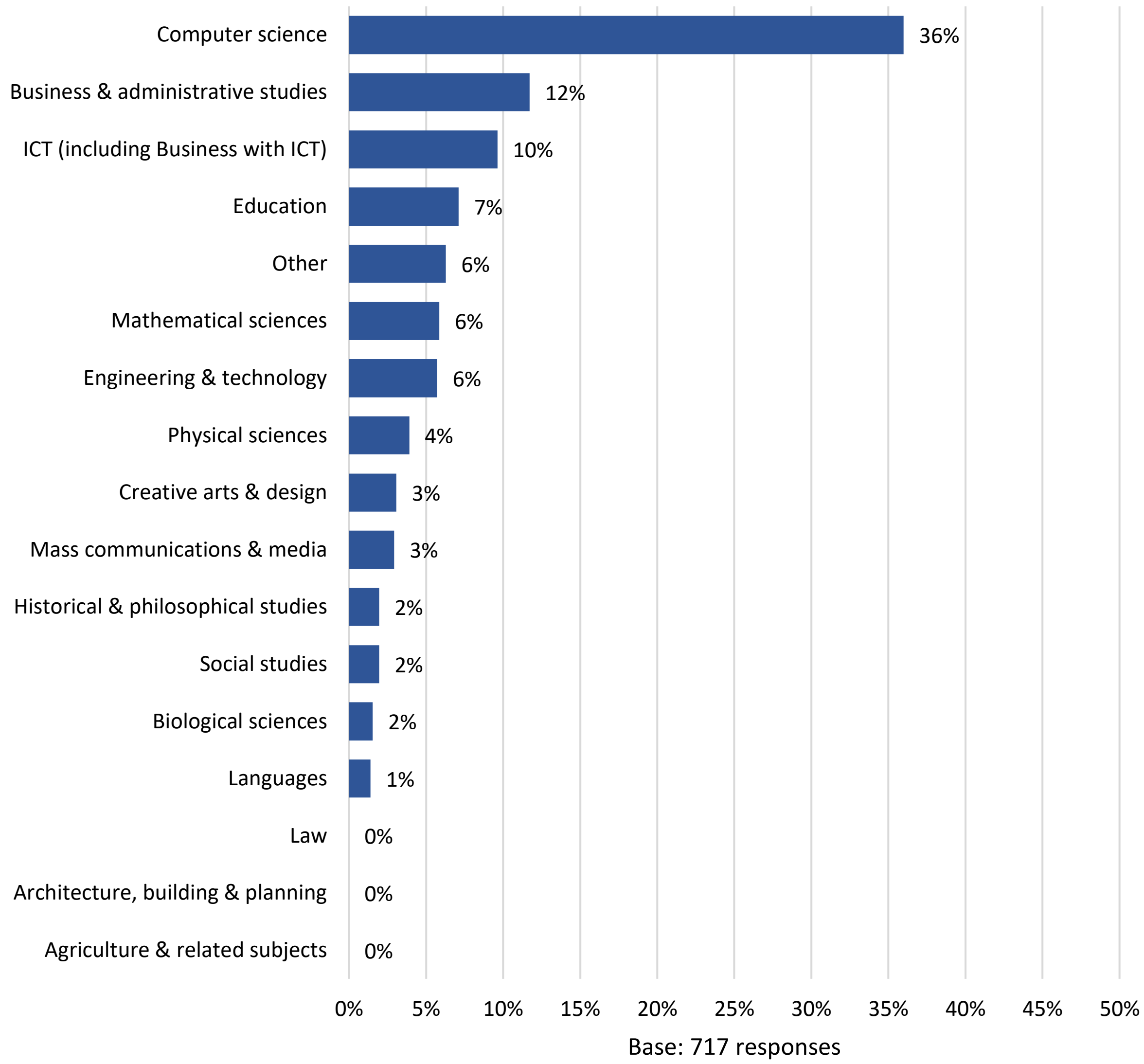
Figure 18 Share of highest qualifications by discipline – primary schools



In secondary schools, computer science accounts for just over a third (36% share) of highest qualifications, followed by business and administration (12% share), then ICT (10% share)[28]. Some computing teachers are qualified in a range of other disciplines, including non-STEM related subjects (Figure 19).

[28] Highest level qualifications classified by secondary school/college respondents as 'Other' included Archaeology, English, Geography and Sports.

Figure 19 Share of highest qualifications by discipline – secondary schools/colleges



As explained in more detail in section 3.1.1, teachers at secondary level in Scotland are required to be qualified in their chosen subject. Table 10 breaks down teachers' highest qualification discipline by nation, which reveals that computer science and mathematical sciences account for a comparatively larger share in Scotland than is the case in England, Wales and Northern Ireland.

While the Department for Education produces national data on the highest 'post A level' qualification discipline of secondary teachers in England, the data are not directly comparable to the survey. The closest matches include 29% of ICT teachers holding a qualification (degree or higher) in the same subject, and 74% of 'Other science' teachers holding a qualification (degree or higher) in the same subject[29].

[29] Department for Education (2016) *School workforce in England – November 2015* (Table 12)

Table 10 Share of highest qualification disciplines by nation

Qualification discipline	UK	England	Scotland	Wales	Northern Ireland
Base responses	**710**	**613**	**57**	**23**	**17**
Computer Science	36%	34%	56%	44%	41%
Business & administrative studies	12%	12%	5%	17%	12%
ICT (including Business with ICT)	10%	10%	2%	13%	6%
Education	7%	7%	7%	9%	6%
Other	6%	7%	-	4%	6%
Mathematical sciences	6%	5%	12%	9%	12%
Engineering & technology	6%	6%	5%	4%	12%
Physical sciences	4%	4%	4%	-	6%
Creative arts & design	3%	3%	2%	-	-
Mass communications & media	3%	3%	-	-	-
Historical & philosophical studies	2%	2%	2%	-	-
Social studies	2%	2%	2%	-	-
Biological sciences	2%	2%	2%	-	-
Languages	1%	2%	-	-	-
Law	1%	1%	2%	-	-
Architecture, building & planning	0%	1%	-	-	-
Agriculture & related subjects	-	-	-	-	-

Table 11 shows the percentage share of highest qualification disciplines by each of the four teacher profiles. This reveals that the Advocates share a comparatively higher proportion of Computer Science qualifications than other groups. In secondary schools in particular, Computer Science accounts for more than half (57% share) of highest qualifications held among Advocates, compared to less than a fifth (17%) among the Less Engaged group.

Table 11 Share of highest qualification disciplines by teacher profile

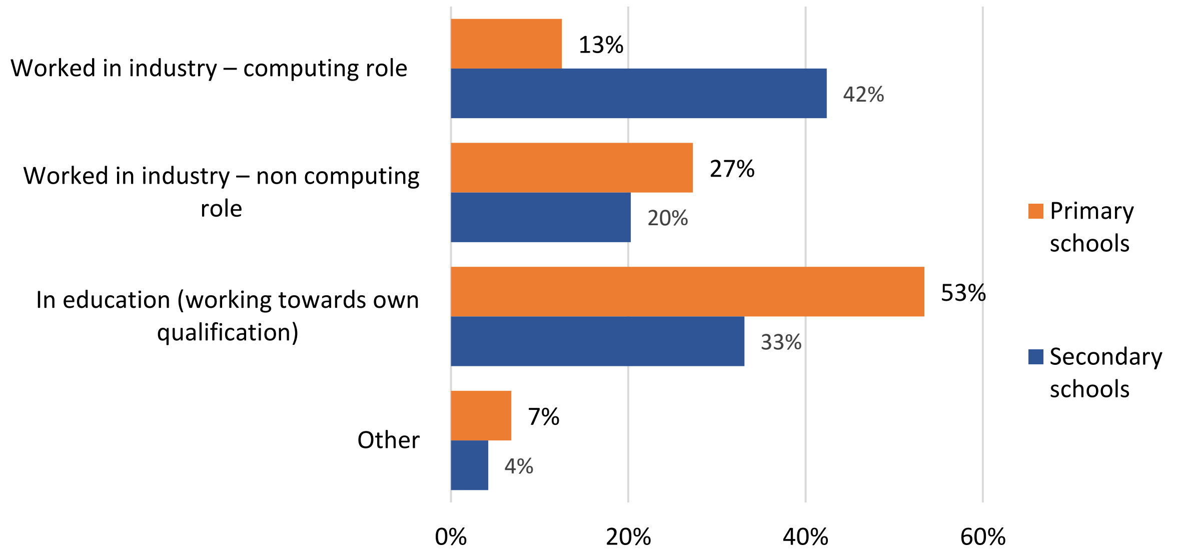
Discipline	Group 1 – Advocates	Group 2 – Supporters	Group 3 – Critics	Group 4 – Less Engaged
Primary				
Computer Science	15%	-	-	3%
Other maths and science disciplines	19%	12%	22%	24%
All other disciplines	66%	88%	78%	72%
Secondary				
Computer Science	57%	33%	39%	17%
Other maths and science disciplines	19%	22%	19%	5%
All other disciplines	25%	44%	41%	79%

3.3.2 Experience

Almost two thirds of surveyed computing teachers (60% of primary teachers and 65% of secondary teachers) have been in the profession for more than 10 years. A small minority (7% of primary teachers and 10% of secondary teachers) joined the profession in the last two years.

Those respondents that had been teaching for less than six years were asked what they were doing directly prior to joining the profession. The results (Figure 20) reveal that in primary schools, more than half of these teachers (53%) were in education and working towards a qualification. In secondary schools, the picture is more varied, with 42% having worked in industry and 33% having been in education.

Figure 20 Position prior to teaching



Base: Primaries (88 respondents) and Secondaries (118 respondents)

3.3.3 CPD

The survey asked teachers for the total number of hours they had individually spent on computing-related Continuing Professional Development (CPD) during 2015-16, along with further details about the nature of those activities[30].

- There are wide variations in the amount and nature of CPD undertaken;
- The most common answer was zero hours (28% of primary teachers and 26% of secondary teachers);
- In primary schools, an average of 11 CPD hours were undertaken in 2015/16, of which more than half (6 hours) were undertaken in surveyed teachers' own time.
- In secondary schools/colleges, an average of 27 CPD hours were undertaken in 2015/16, and almost all (22 hours) were undertaken in surveyed teachers' own time. This indicates a lack of time in the school day and potentially meaning that teachers with many commitments outside of work could face difficulties fitting this in.

[30] In order to understand what teachers classify as CPD, the survey did not provide a hard and fast definition of this term, nor did it specify how teachers should define the working day versus their "own time".

Figures 21 and 22 show the percentage of surveyed teachers reporting CPD using bandings for total CPD hours. The distributions reveal the variation in amounts of activity undertaken in both primary and secondary schools.

Figure 21 CPD banded hours in 2015/16 – primary schools

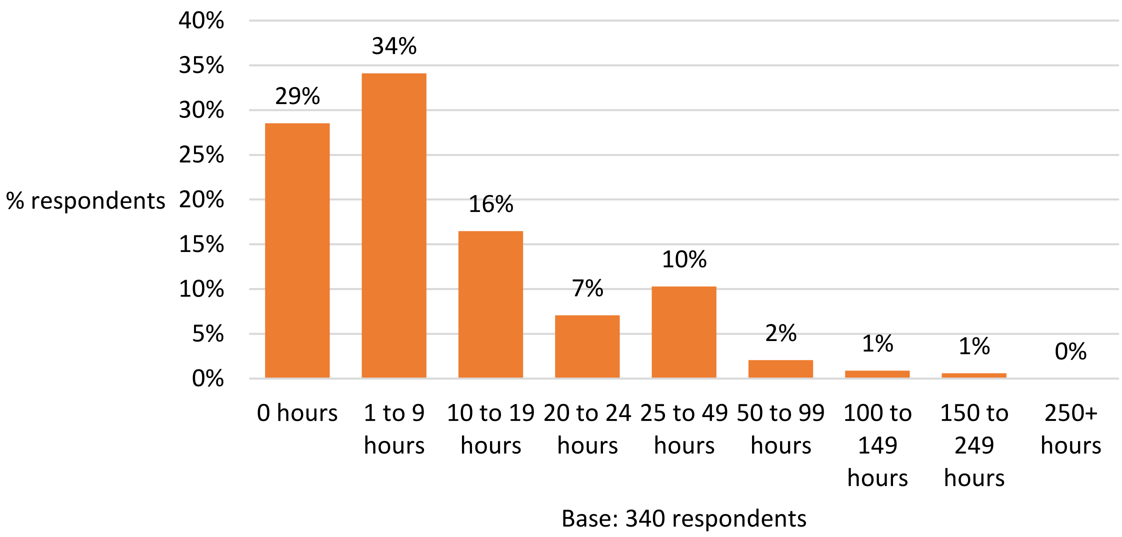
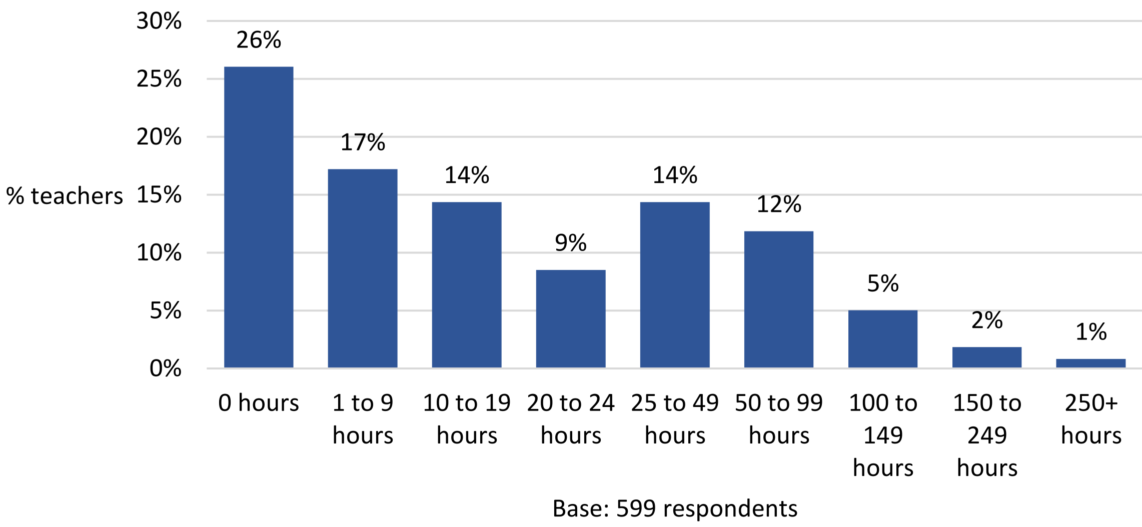


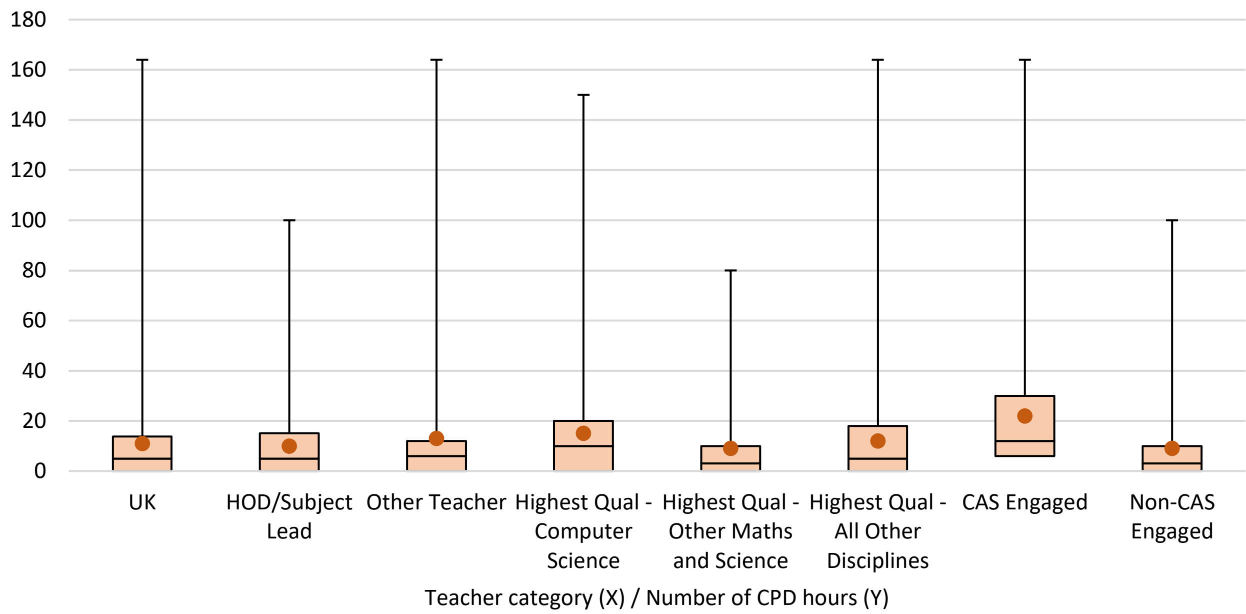
Figure 22 CPD banded hours in 2015/16 – secondary schools

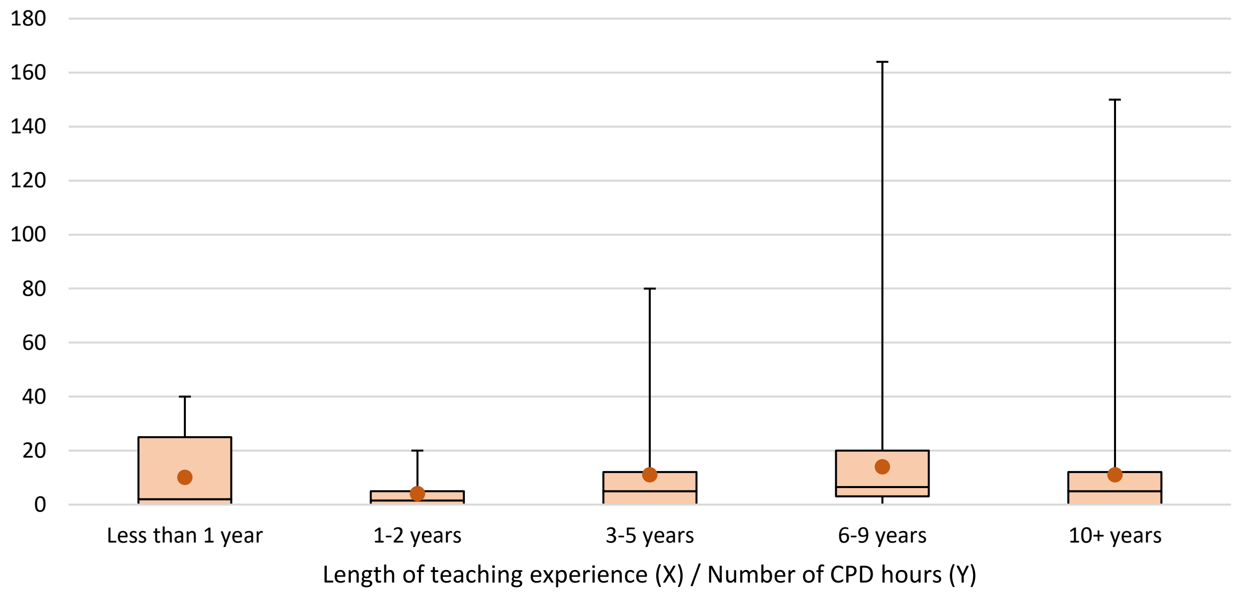


Box plots[31] of CPD activity are shown in Figures 23 and 24, with the maximum reported by a primary teacher being 164 hours and the maximum by a secondary teacher being 300 hours[32].

Reported CPD time is highest among CAS-engaged teachers (especially in primary schools), secondary teachers in Scotland, as well as the teachers falling into the 'Advocates' profile.

Figure 23 CPD hours in 2015/16 – primary schools (box plots)





[31] **Key to the box plots:** Mean = coloured spots; 1st Quartile and 3rd Quartile = lower and upper limits of the coloured boxes; Median = horizontal line within the coloured boxes; Range = lower and upper limits of the whisker lines.
[32] These maximum figures already take into account the removal of outliers.

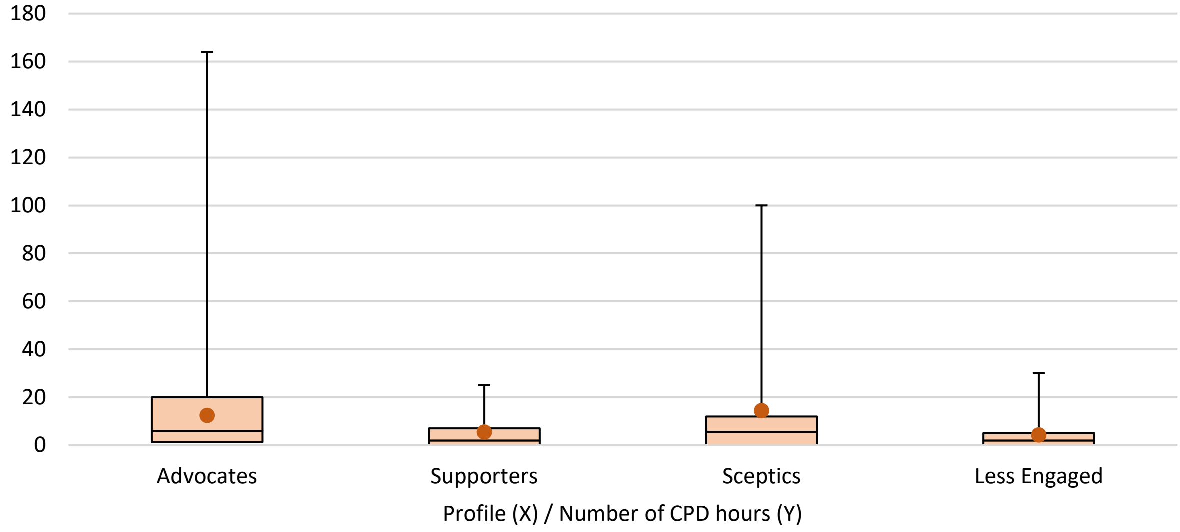
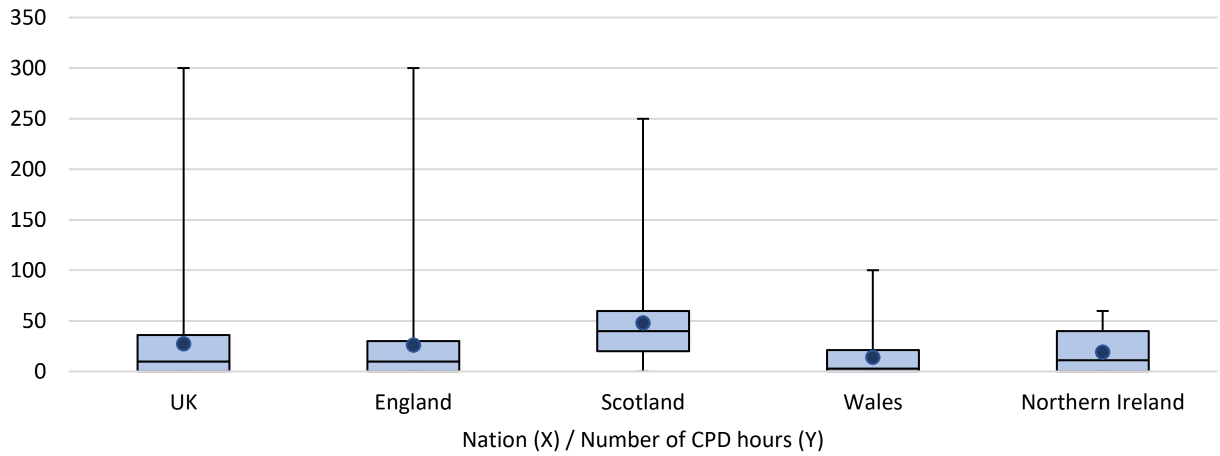
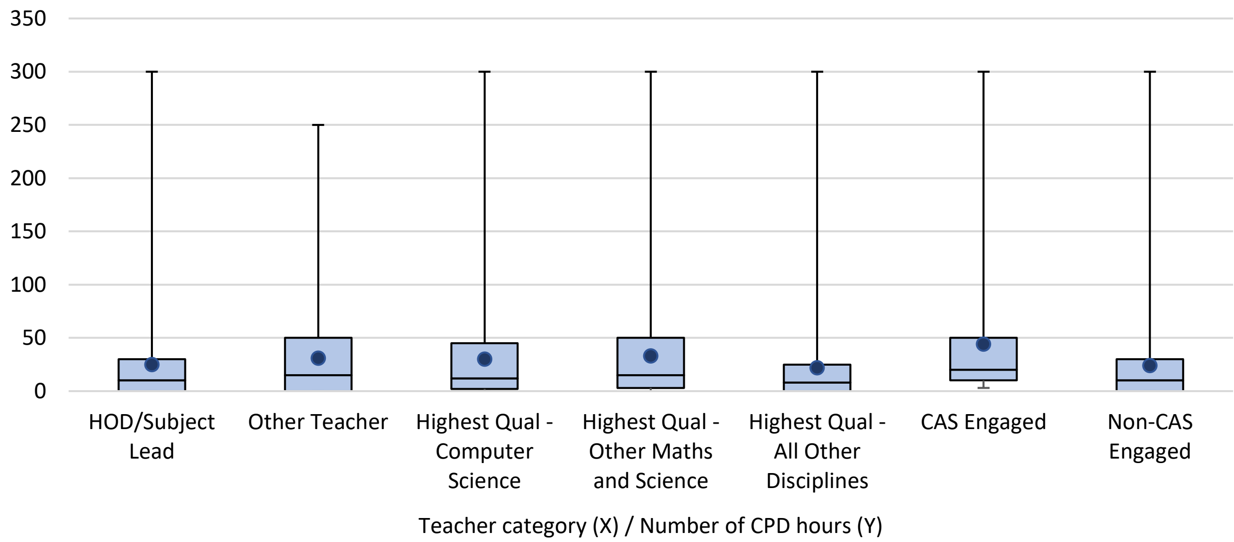
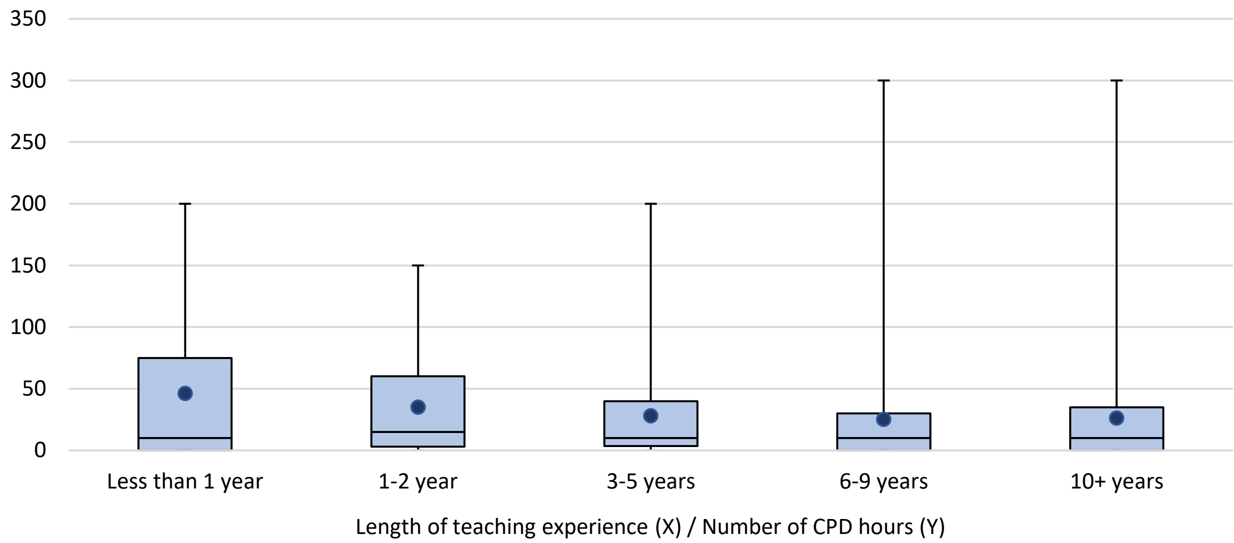
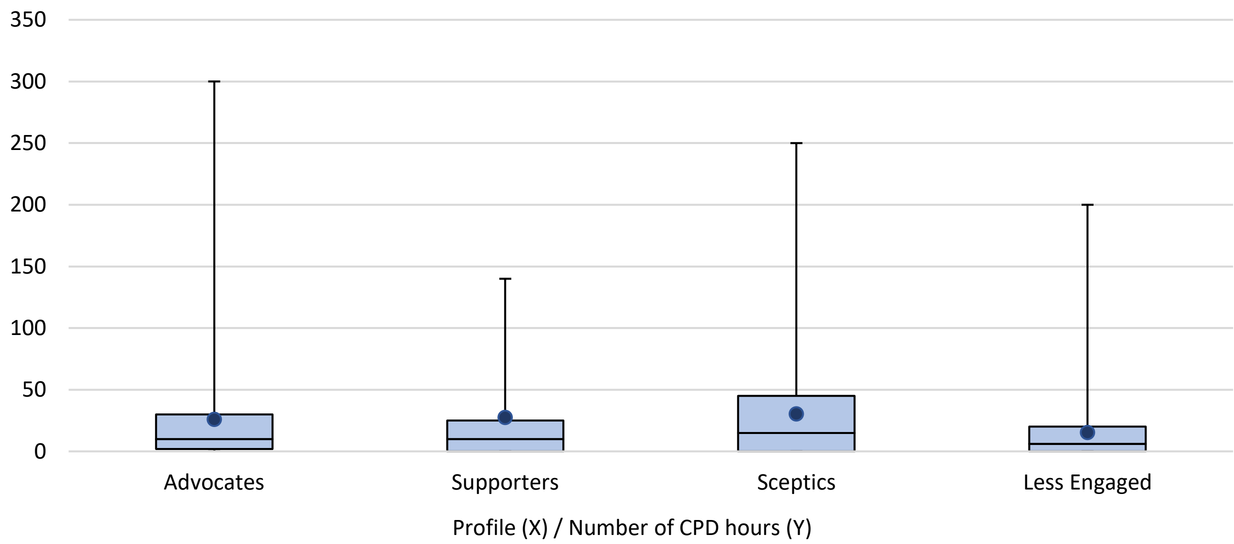


Figure 24 CPD hours in 2015/16 – secondary schools/colleges (box plots)



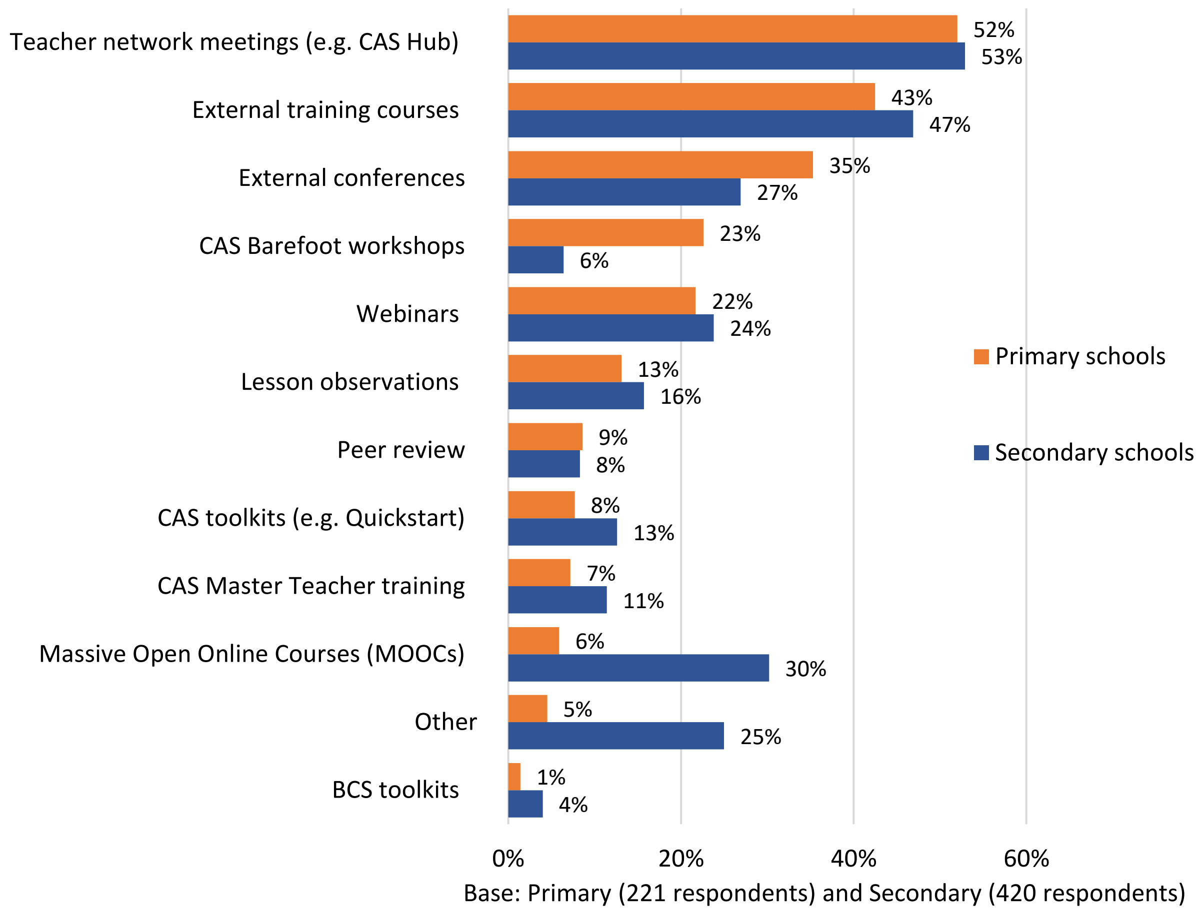






A variety of computing-related CPD activities are undertaken in schools and colleges. The percentage of surveyed teachers undertaking different types of activities is shown in Figure 25. The most common among primary and secondary teachers is teacher network meetings (e.g. CAS hubs), followed by external training courses. More secondary than primary teachers appear to be making use of Massive Open Online Courses (MOOCs). The reasons why are not clear from this research alone, with one possibility being that secondary teachers are more familiar with this terminology.

Figure 25 Types of CPD activity



"I strive to keep up with technological developments and this is one area that takes a lot of time and is constantly changing, so it's no easy task."

Computing Coordinator, Primary School

Table 12 shows the percentage of surveyed teachers (primary and secondary) that have been involved in CAS-related CPD across the four teacher profiles. This reveals that Advocates have been most involved in CAS-related CPD, whilst in primary schools particularly, the Less Engaged group have had less involvement in CAS-related CPD.

Table 12 CAS Engagement by teacher profiles

Level	Group 1 – Advocates	Group 2 – Supporters	Group 3 – Critics	Group 4 – Less Engaged
Primary	28%	10%	13%	7%
Secondary	20%	17%	16%	16%

3.4 Chapter Summary

Analysis of teachers' understanding of computational thinking (on a scale from 1 'no understanding' to 10 'complete'), reveals that more than half of primary teachers (52%) and three quarters of secondary teachers (75%) surveyed gave a rating of 8 or higher. The observed distribution among primary teachers spans the full 1 to 10 range, is generally mixed and roughly exponential among secondary teachers. This indicates wide variations in levels of teacher understanding and it is a statistically significant finding that teachers who hold their highest qualification in Computer Science have a better understanding of computational thinking than those qualified in another discipline.

Secondly, analysis of schools' favourability towards the new computing curriculum (on a scale from 1 'not at all' to 10 'completely') reveals varying teacher attitudes. Almost two third of primary teachers (65%) compared with less than half of secondary respondents (38%) surveyed gave a rating of 8 or higher. The observed distribution of ratings given by secondary schools/colleges is more dispersed than primary schools.

By cross-tabulating how teachers rated their understanding and favourability, it has been possible to derive four teacher profiles. These are summarised as follows:

Advocates group: Strong understanding of computational thinking and high favourability towards the computing curriculum.
Supporters group: Comparatively less understanding of computational thinking but high favourability towards the computing curriculum.
Critics group: Strong understanding of computational thinking but comparatively low favourability towards the computing curriculum.
Less Engaged group: Comparatively less understanding of computational thinking and comparatively low favourability towards the computing curriculum.

Those teachers favourable to the new curriculum described the importance of computing education keeping up with the pace of industry and technological change. They added that computational thinking is a vital cross-curricula skill and that the reformed computing qualifications are more interesting, creative and challenging than traditional ICT, which is viewed as somewhat vague and monotonous by comparison.

A key concern from those teachers less favourable to the new computing curriculum, particularly in secondary schools/colleges, is that the balance of content is weighted too heavily towards computer science and that vital and fundamental ICT skills are at risk of being side-lined. There is also some concern that the new curriculum has been implemented in England without sufficient regard to who would teach it and the potential amount of additional knowledge/upskilling that may be required by teachers.

On a scale from 1 'not at all confident' to 10 'completely confident', teachers rated their confidence in delivering the curriculum at each distinct Key Stage/level. Levels of confidence are lower among surveyed secondary schools than primary schools, and there is a drop in the mean confidence rating across each successive level of secondary education, from 8.5 at Key Stage 3, down to 6.6 at A level/equivalent. Looking across the four teacher profiles, Advocates are the most confident in delivering the curriculum, while the Less Engaged group of teachers are the least confident.

Analysis of confidence levels relating to specific aspects of curriculum delivery reveals that schools are more confident in relation to some aspects than others. To improve levels of confidence, schools are calling for more training to improve their subject knowledge, make the most of curriculum opportunities, better understand qualification grade boundaries, identify how to get the most out of mixed ability classes, and be able to teach more complex aspects of computing theory.

Looking at the highest level qualifications held by teachers with at least some responsibility for computing education, the survey has identified a range of background disciplines, be it in STEM subjects, humanities or the arts. Looking across the four profiles, Advocates share a comparatively higher proportion of Computer Science qualifications than the other groups.

Finally, the survey examined the total number of hours spent by teachers on computing-related CPD during 2015-16, along with further details about the nature of those activities. The most common answer was zero hours (28% of primary teachers and 26% of secondary teachers) however there are wide variations in the amount and nature of CPD undertaken. The most common is teacher network meetings (e.g. CAS hubs), followed by external training courses. Looking across the four profiles, Advocates have been the most involved in CAS-related CPD.

4. Teaching and Assessment Approaches

The research has revealed that computing education opens the door to a variety of creative approaches to teaching, as well cross-curricular links with other subjects. Support from senior leadership teams is considered important, as is the rich array of educational resources that can help to make computing engaging and interesting for learners. A range of practices (including examples of obstacles faced) are explored below, along with approaches to assessment.

4.1 Pedagogy

A range of pedagogical approaches are used by teachers, for example:

- Direct explanation of concepts and theory;
- Use of worksheets that enable students to execute codes in programmes, e.g. making animated characters perform a particular action;
- Extended tinkering, e.g. as part of class competitions to be the first to programme a robot to throw a ball to a set distance/direction;
- Project based work such as designing web content and working with audio-visual technology; and
- 'Unplugged' activities so that students can learn computational thinking without needing hardware.

Unplugged activities require imagination but can be cost-effective, especially when there may not be enough hardware for every student. In one case study primary school, teachers set activities for pupils to find instructions where logic processes needed to be followed, for example the steps needed to successfully operate a fire extinguisher.

"There are amazing things you can do with very little."

Computing Subject Leader, Primary school

An especially successful approach in computing is 'trial and error', which involves embedding the mind-set among students that making mistakes is OK, moreover that this is necessary to working through a logic problem. One way teachers do this, especially for the younger year groups, is to talk about certain activities as 'games', which helps to make learning more engaging.

Another common approach is 'copy coding', where the teacher explains a concept/scenario and students replicate instructions, usually to reach a single solution. This can sometimes involve spotting and debugging a deliberately inserted error. Assessment of this approach tends to focus on how far students got with the activity, how many attempts it took, and speed of completion.

Primary school participants in the discussion groups and case studies described how they engage pupils by relating work to popular cultural identities, such as animating characters from the films *Star Wars* and *Frozen*. One secondary teacher advocated having a bank of different types of programmes available for use in class, which can be selected depending on whether students are more artistically or mathematically minded, in order to make the subject as appealing as possible.

The case study visits found that particular approaches tend to suit some students better than others, depending on how they prefer to learn. One of the Year 10 girls at a secondary school said she prefers it when the teacher spends more time explaining things in detail before the practical work begins, however a Year 9 boy said that he doesn't like to spend too long on the theory and prefers "having a go".

"There's an element of trial and error. If the students are already enthusiastic about programming I give them an individual project and they get on with it. For the rest of them I direct my attention to explaining the concept, whilst all the time walking around the room to see how they are getting on with it on the computer."

Head of Computer Science, Secondary School

More detailed research would be needed to examine the relative effectiveness of different pedagogical approaches in practice and how well these engage students and help them to think independently.

4.2 Cross-Curricular Links

Computing offers a number of cross-curricula links. In one of the case study primary schools, a teacher had the idea of creating a floor mat designed with local landmarks, with pupils learning about their local area by programming a bee bot[33] to navigate its way between different points.

In a secondary school, a year 10 pupil described how computing "changes the way you think", which has helped her to break down and tackle complex problems in maths. A secondary teacher at the London discussion group described how the concept of 'debugging' can be applied to word editing and therefore developed through English lessons.

In secondary schools, forging links with other departments can be constrained by time and a misperception that the computing curriculum is too narrow. Schools also mentioned facing

[33] A bee bot is a programmable floor robot in the shape of a bee. It has a simple layout of function button (forward, rotate left, rotate right, stop etc.) teaching control, directional language and programming to younger children.

resistance from other departments, be it due to competing pressures or a lack of understanding about computing education, thus missing out on potential cross-curricular opportunities.

"The new computing curriculum uses and applies maths skills and helps to develop children's online safety awareness. This is very important in today's society."

Computing teacher, Primary school

"As a science teacher I believe the role of computing needs to be better recognised as a science."

Computing teacher, Secondary school

4.3 Access to Teaching Support

4.3.1 Senior Leadership Teams

In several of the discussion groups, teachers emphasised how the buy-in and attitude of senior leadership teams to computing can make a big difference to the culture in the school, attitude of all staff towards computing, and the level of investment in professional development and other resources.

In some primary schools, the focus appears to be very much on core subjects such as maths and English, whereas in others, computing can be given greater priority where the head teacher considers it a valuable subject for young people to learn. Participants at the Cardiff workshop explained that computing gets side-lined where senior leaders believe there to be other subjects most likely to generate the best student grade performance, rather than investing in the subject for the longer term.

In Belfast it was noted that the 'image' of Computer Science can be a barrier, for example where the subject is perceived by senior leaders as 'specialist' rather than 'mainstream'. It was also argued at the discussion group that teachers and parents may be more likely to encourage students to follow an alternative and "easier" subject where they stand the chance of getting a higher grade that will help them progress to university.

At the Plymouth discussion group, one participant explained how senior leaders should be recognising where teachers of other subjects could be particularly successful in delivering computing, particularly where they have relevant industry experience or have shown enthusiasm for the subject. It appears that this does not always happen, with one report of a teacher having left her position because she wanted to teach the subject but wasn't given the chance.

4.3.2 External Organisations and Resources

The research revealed anecdotal evidence of an exponential growth in the amount of teaching resources following the introduction of the new curriculum in England, with many commercial organisations and suppliers now tapping into the schools market. This can make it difficult for teachers to know what to select and trust, with examples given of hugely expensive packages which have turned out to be disappointing. Some schools have found it useful to partner with one another to share resources, with examples given in the Edinburgh discussion group of universities supporting schools, for example by providing exemplar lesson materials or running tutorials for students.

Survey respondents were asked to list the three most beneficial organisations or resources that they have drawn on to improve the effectiveness of computing education in their schools. The resulting lists are shown in Table 13 (primary) and Table 14 (secondary)[34]. Entries are ranked by percentage share of total responses and the top 10 in each list are shaded.

Table 13 Most beneficial supporting organisations and resources – primary schools

Barefoot	17.7%	Google	1.0%
Computing At School (CAS)	15.3%	Lego Education	1.0%
Scratch	11.4%	Thinkyouknow	1.0%
Rising Stars	6.5%	2Simple	0.7%
Purple Mash	5.3%	BT	0.7%
Code.org	2.9%	Code for Life	0.7%
Espresso	2.9%	Education City	0.7%
Code Club	2.7%	Future Learn	0.7%
Switched On Computing	2.7%	Twitter	0.7%
Hour of Code	2.4%	3BM	0.5%
Raspberry Pi	1.9%	BETT Show	0.5%
Twinkl	1.7%	Computer Science Unplugged	0.5%
BBC	1.5%	DASCO	0.5%
CEOP	1.5%	Discovery Coding	0.5%
Code It	1.5%	Glow Scotland[35]	0.5%
Phil Bagge resources	1.5%	Icompute	0.5%
National STEM Centre	1.5%	Kodu	0.5%
Tablets	1.5%	Microsoft	0.5%
Apple	1.2%	NAACE	0.5%
LGFL	1.2%	Openzone CLC	0.5%
Common Sense Media	1.0%	Simon Haughton	0.5%
DB Primary	1.0%	YouTube	0.5%

[34] To delimit the number of entries, an organisation/resource qualifies for inclusion in these lists if mentioned by at least two respondents.
[35] Mentioned by four Scotland-based teachers only.

Table 14 Most beneficial supporting organisations and resources – secondary schools

Computing At School	36.5%	Google	0.6%
OCR	5.2%	Khan Academy	0.6%
TES	5.2%	CS4FN	0.5%
Teach ICT	4.1%	Edge Hill	0.5%
PG Online	3.4%	Scholar	0.5%
Facebook Groups	3.3%	WJEC	0.5%
BBC (Micro:bit/Bitesize)	3.1%	Codio	0.3%
Zig Zag	2.1%	MIT	0.3%
Code Academy	1.8%	Nichola Wilkin	0.3%
Raspberry Pi	1.7%	Pixl	0.3%
Cambridge Resources	1.6%	Southampton University	0.3%
National STEM centre	1.5%	University of Warwick	0.3%
Scratch	1.4%	Adobe	0.2%
YouTube	1.3%	Arduino	0.2%
AQA	1.1%	Axsied	0.2%
BCS, The Chartered Institute for IT,	1.1%	Barefoot	0.2%
Python	1.1%	Compute-IT	0.2%
W3Schools	1.1%	Computerphile	0.2%
Code Academy	1.0%	Dynamic Learning	0.2%
Code.org	1.0%	Exampro	0.2%
Craig and Dave	1.0%	Future Learn	0.2%
Hodder Education	1.0%	Glow Scotland[36]	0.2%
Hour of Code	1.0%	Grok Learning	0.2%
Alan O'Donohoe/EXA Foundation	0.9%	Kodu	0.2%
Computer Science UK	0.9%	Kings College London	0.2%
Exam Boards (generic)	0.9%	Minecraft	0.2%
CompEdNet	0.8%	MMU	0.2%
Pearson Edexcel	0.7%	Queen Mary's University London	0.2%
Microsoft	0.7%	Repl.it	0.2%
Plan C	0.7%	Royal Society of Edinburgh (RSE)	0.2%
Stack Exchange/Overflow	0.7%	Sheffield Hallam University	0.2%
Techno Camps	0.7%	SWAT	0.2%
AOK Learning	0.6%	Teaching London Computing	0.2%
Code Club	0.6%	theteacher.info	0.2%

"CAS has been a God-send to me… The people at CAS are educators, so everything is pitched at the right level. That's why their lesson plans and activities are so effective."

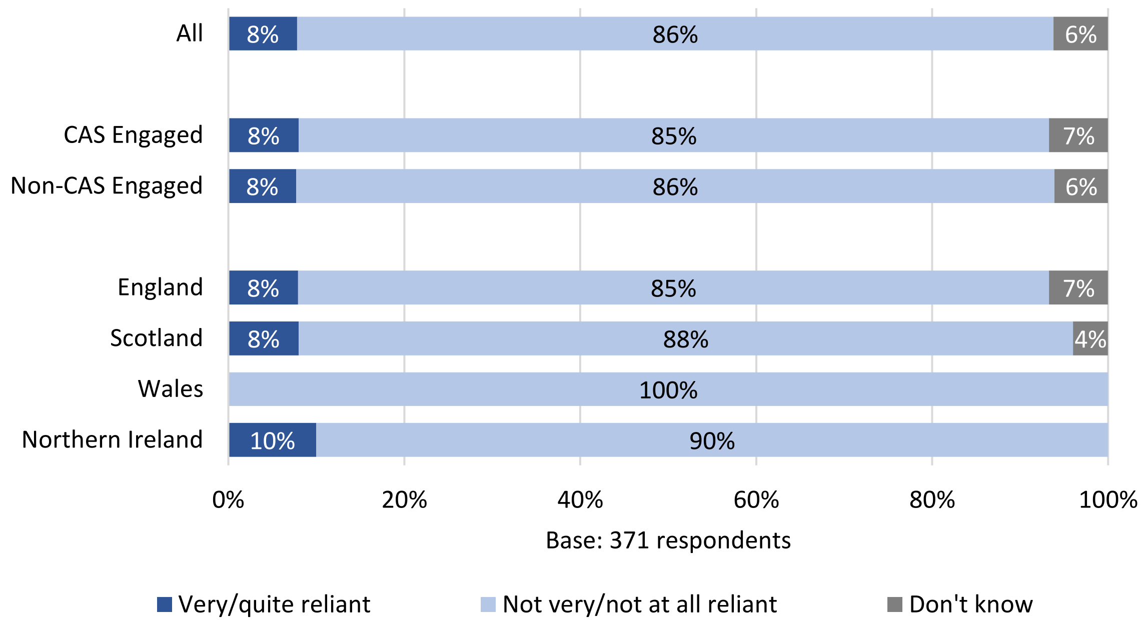
Head of Computing, Secondary school

[36] Mentioned by two Scotland-based teachers only.

Other types of support have included working with local cluster groups of schools (including resource sharing between primary and secondary schools), attending teacher networking meetings and computing conferences, as well as meetings and seminars organised by local authorities, awarding organisations and STEM Centres. Some schools have also engaged directly with subject specialists at local colleges and universities, and made links with industry to facilitate work taster days and arrange for employer talks in the school.

Secondary schools were asked a further question to gauge how much they depend on help and support provided by volunteer experts. The majority (86%) are not reliant on this type of support (Figure 26).

Figure 26 Reliance on help and support from volunteer experts – secondary schools/colleges



4.3.3 Online Groups and Forums

Just under a third of primary schools (27%) and almost of half of secondary schools (47%) are reliant on help and support provided by online groups and forums to deliver computing. This is especially the case among CAS engaged respondents, suggesting they may have a greater awareness of online support channels and confidence in knowing what to trust (Figures 27 and 28).

The fact that such a large proportion of schools do not rely on this kind of online support suggests that they either consider themselves to be already proficient (where this may or may not always be the case), prefer to use other types of resources, or feel unable to access online support for whatever reason.

Figure 27 Reliance on help and support from online sources – primary schools

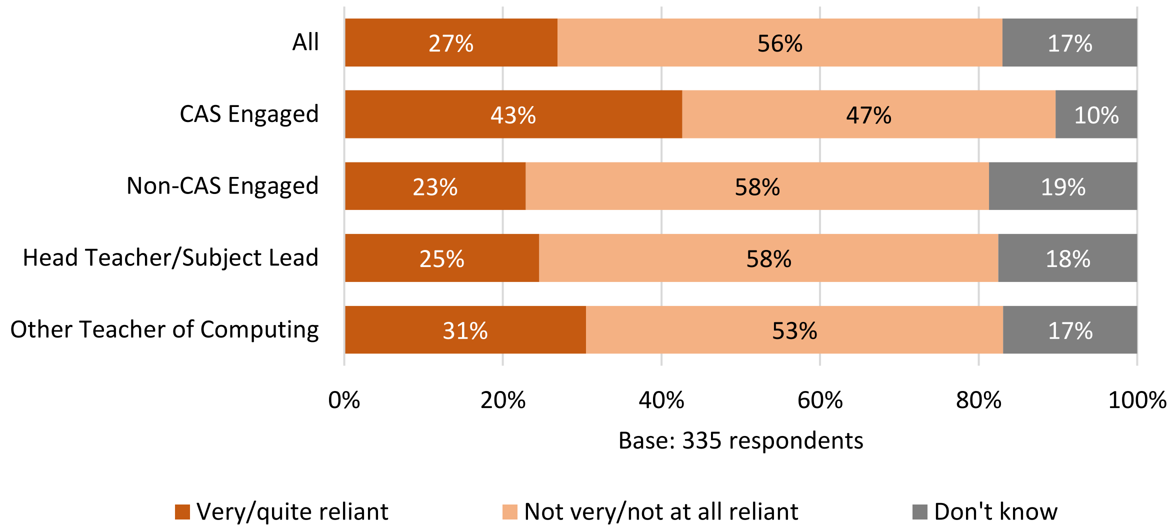
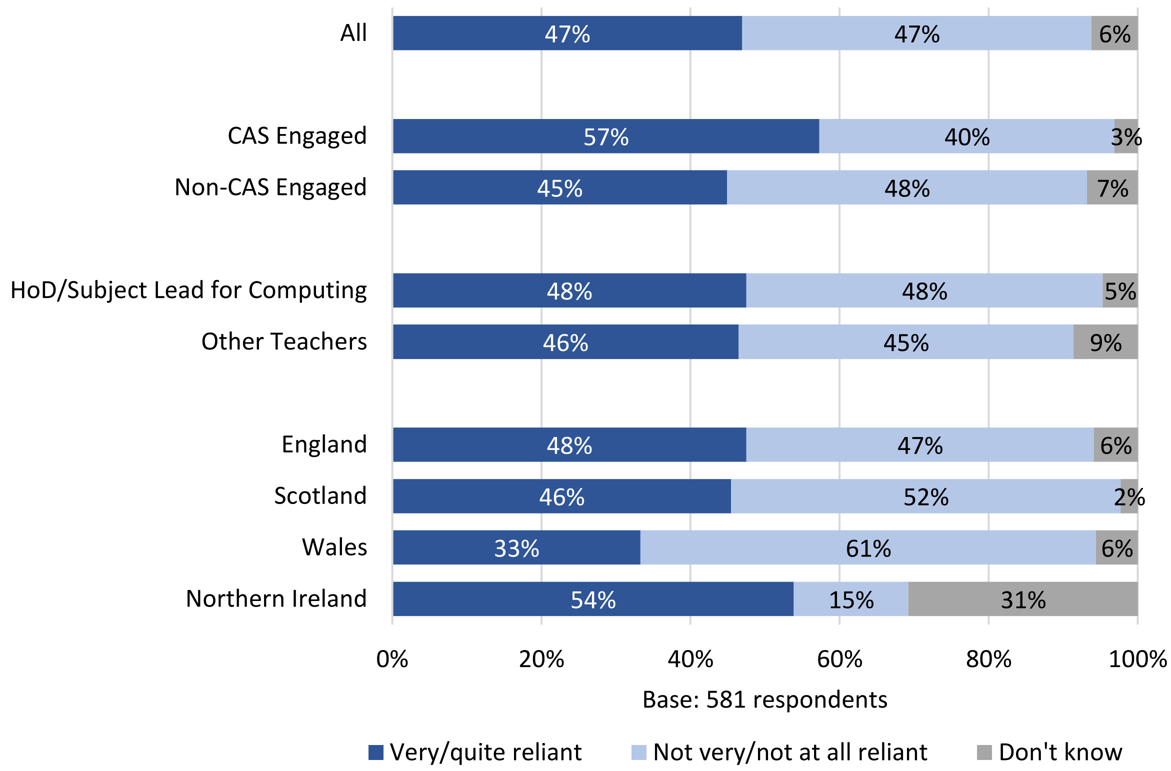


Figure 28 Reliance on help and support from online sources – secondary schools/colleges



The five most commonly mentioned online groups and forums that schools find most useful are set out in Table 15, below

Table 15 Online groups and forums that schools find most useful

Primary schools	Secondary schools
CAS, including Barefoot Computing (26 respondents) Twitter, e.g. #caschat (16 respondents) TES (7 respondents) Facebook groups (5 respondents) Purple Mash (2 respondents) and Education Scotland (2 respondents)	CAS, including online hubs, use of teaching resources, ideas sharing, and a place to source up-to-date knowledge and information (217 respondents) Facebook groups, in particular the OCR computing group (143 respondents) TES (30 respondents) CompEd.net (23 respondents) Stackoverflow.com (17 respondents)

"If there is a need for further support it is probably in taking the structured style of Code.org and extending it to cover more in depth concepts to support programming beyond the elementary level."

Deputy Head Teacher, Secondary School

4.3.4 Programming Languages

Schools were asked which programming languages/tools they use as part of computing education. The top three used by primary schools are Scratch, Logo and Kodu (Figure 29) and the top three used by secondary schools are Python, Scratch and JavaScript (Figure 30).

Figure 29 Programming languages – primary schools

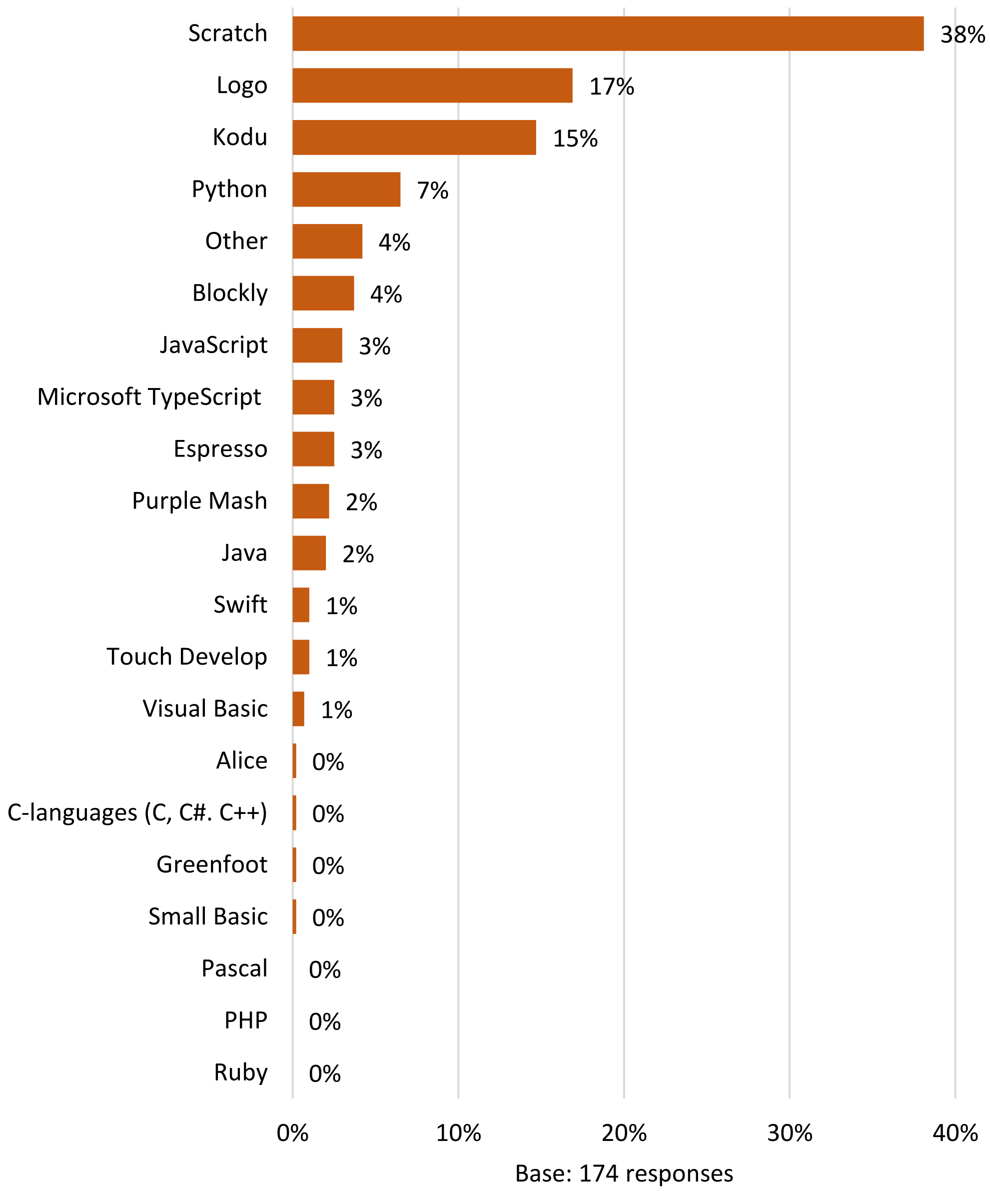
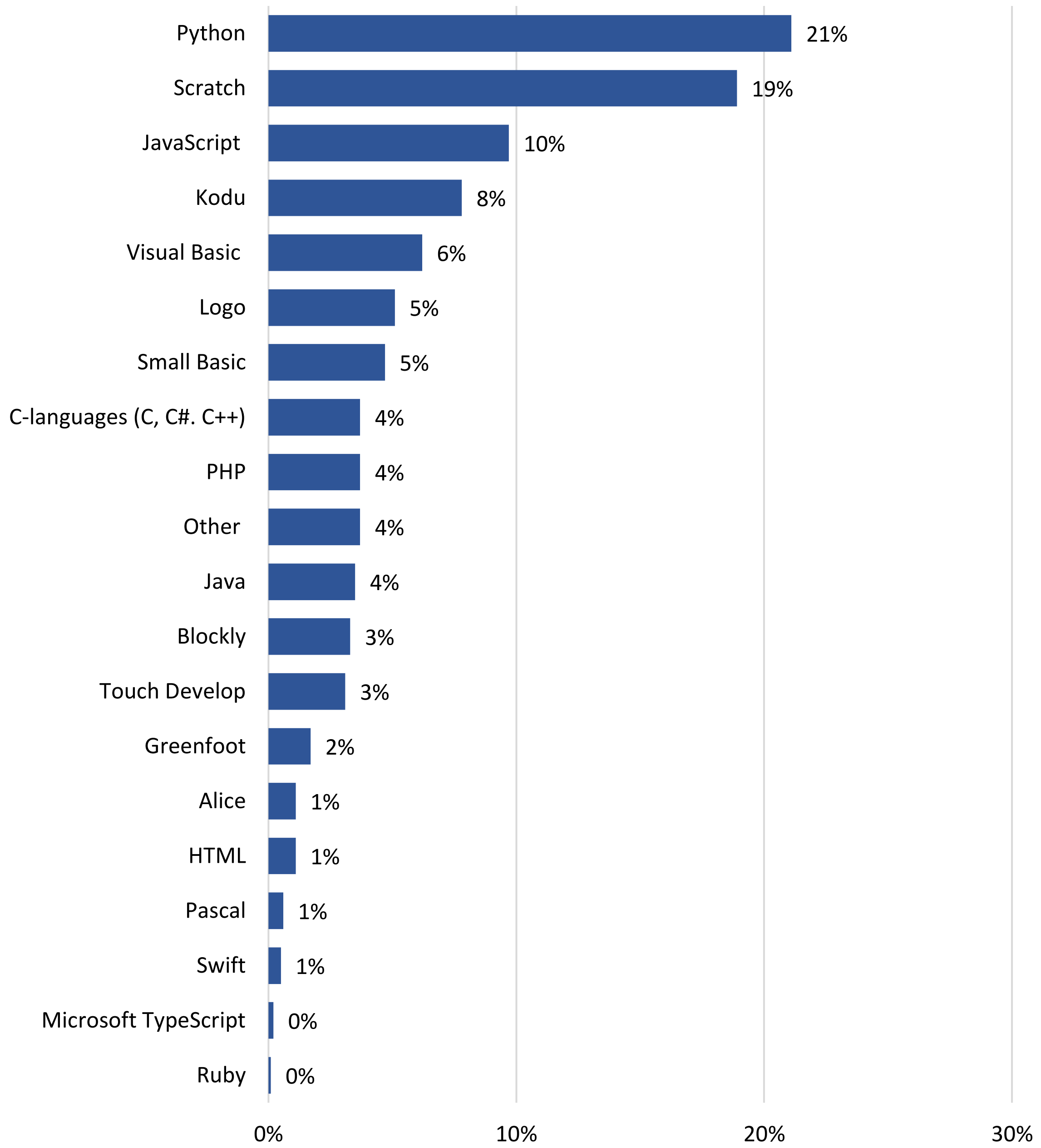


Figure 30 Programming languages – secondary schools/colleges



Base: 1,508 responses

4.4 Assessment

In the discussion groups, primary schools described how the absence of a formal assessment regime gives teachers the freedom to experiment with the subject and try new things, which they value strongly.

In secondary schools, there is mixed evidence of formative and summative assessment approaches, for example some schools assess computational 'behaviours' such as problem solving on an on-going basis, whilst others prefer to use a 'tick-box' approach to monitor the completion of specific topics – with the latter tending to be more common.

Key Stage 3 reportedly allows more flexibility in assessment, with several examples of teachers explaining a concept and setting a task at the start of a lesson, followed by students undertaking computer-based work, saving their progress in an electronic folder, and then being awarded a mark based on their progress.

In Plymouth there was some discussion around written versus oral assessments, notably that a verbal explanation of how a student would solve a problem is not necessarily less valuable than a written one, such as annotating screen shots. It was argued that in the world of work, oral explanations and demonstrations are an important skill; furthermore that this might better suit those students who have a great problem solving mind but find it more difficult to articulate their reasoning on paper.

GCSE and A level Computer Science specifications attracted some criticism through the survey and discussion groups for being difficult to interpret and containing too much content, which can lead to the syllabus being rushed and corners cut. In Birmingham, participants referred to the sheer volume of content being partly responsible for ICT elements being "squeezed out", and a participant in Belfast commented that "the complexity and volume far exceeds any other GCSE" and that "it's almost at A level standard".

Several teachers mentioned receiving insufficient guidance from awarding organisations around performance benchmarks and grade boundaries, and criticised the controlled assessments for taking up too much time, with teachers describing these assessment approaches as "soul destroying" and "nightmarish".

"There's no way we'll get through the GCSE in time for the summer exams".

Computing teacher, Secondary school

4.5 Chapter Summary

The research has revealed that a variety of pedagogical approaches are used by computing teachers. These include direct explanation of concepts and theory; use of worksheets that enable students to execute codes in programmes; extended tinkering (e.g. as part of class competitions); project based work; and 'unplugged' activities whereby students learn computational thinking in creative ways without needing access to hardware. An especially successful approach in computing is 'trial and error', which involves embedding the mind-set among students that making mistakes is an important part of solving a logic problem.

Computing also offers cross-curricula links, for example computational thinking appears to be helping some pupils in their approach to solving problems in maths and can be used to tackle word editing and structuring poetry in English.

In terms of support available for computing teachers, a key theme raised in the discussion groups is that the buy-in and attitude of senior leadership teams to computing can make a big difference to the attitude of staff towards computing and the level of investment in professional development and other subject-specific resources.

Schools draw on support from a wide range of external organisations and resources, with the top three among surveyed primary schools being Barefoot, CAS and Scratch. In surveyed secondary schools/colleges, CAS resources account for more than a third (37%) of all external resources used. Due to reports of an exponential rise in the number of teaching materials and resources coming to market since the changes to the curriculum, teachers report finding it difficult to know what to select and trust.

A minority of surveyed schools (27% of primary schools and 47% of secondary schools/colleges) say they are reliant on help and support provided by online groups and forums to deliver computing. This finding suggests that the majority either consider themselves to be already proficient, prefer to use other types of resources, or feel unable to access online support for whatever reason.

Finally, the topic of assessment was covered in the discussion groups, with primary schools describing how the absence of a formal assessment regime for computing gives teachers the freedom to experiment with the subject and try new things, which they value strongly. In secondary schools, there is mixed evidence of formative and summative assessment approaches, for example some schools assess computational 'behaviours' such as problem solving on an on-going basis, whilst others prefer to use a 'tick-box' approach to monitor the completion of specific topics. GCSE and A level Computer Science specifications attracted some criticism through the survey and discussion groups for being difficult to interpret, containing too much content (which can lead to the syllabus being rushed and corners cut), and being supported by insufficient guidance from awarding organisations, particularly around performance benchmarks and grade boundaries.

5. The Learning Environment

The way computing education is coordinated in schools provides an indication of how highly the subject is prioritised among others. This section examines timetables hours, specialist and non-specialist teachers (including shared subject responsibilities), budgets allocated to computing, trends in investment (financial and non-financial), as well as the adequacy of physical resources and teaching space. It goes on to explore how computing is delivered beyond the classroom, including the types and frequency of extra-curricular activities.

5.1 Timetabled Hours

For surveyed primary schools in England, Wales and Scotland[37], the most common (modal) amount of computing education undertaken by each pupil in 2015/16 was one hour per week. This ranges from zero hours (mentioned by seven schools in England and one in Scotland) to four hours (mentioned by one Voluntary Controlled school in England and one local authority school in Scotland).

In secondary schools/colleges in England, Wales and Northern Ireland, the most common answer for each year of Key Stage 3 was also one hour per week. This ranges from zero hours (25 schools) to three hours (23 schools). A total of four surveyed schools reported no computing education at all at Key Stage 3 (i.e. Years 7, 8 or 9).

The most common answer at GCSE was three hours and at A level five hours per week. These modal answers appear higher than expected and should be treated with some caution. It is not clear whether some schools may have reported more than one subject together, for example where students have been taking both ICT and Computer Science, or other computing-related qualifications alongside a core GCSE/A level. For these reasons further analysis has not be conducted on these results.

In Scotland, the most commonly reported number of hours was one hour per week at levels S1 and S2, rising to two hours at S3, then increasing to four hours at S4 and five hours at levels S5 and S6.

5.2 Specialist and Non-Specialist Teachers

Table 16 shows the average number of full time equivalent (FTE) staff with at least some responsibility for delivering computing education per surveyed school.

[37] There are insufficient data to report timetabled hours for primary schools in Northern Ireland.

In primary schools, aspects of computing are delivered by general class teachers as part of the wider curriculum. That said, the primary school case studies and some discussion group conversations revealed how the presence of one or more specialist teachers can be especially helpful, for example: identifying and selecting teaching resources, acquiring equipment, spreading enthusiasm, encouraging other staff to participate in CPD, as well as building links such as with other schools and industry.

Secondary schools and colleges appear to have a mix of specialist and non-specialist teachers delivering the subject. This was observed in one of the case study schools, where two maths teachers had been temporarily deployed to deliver computing alongside two other specialist computing teachers.

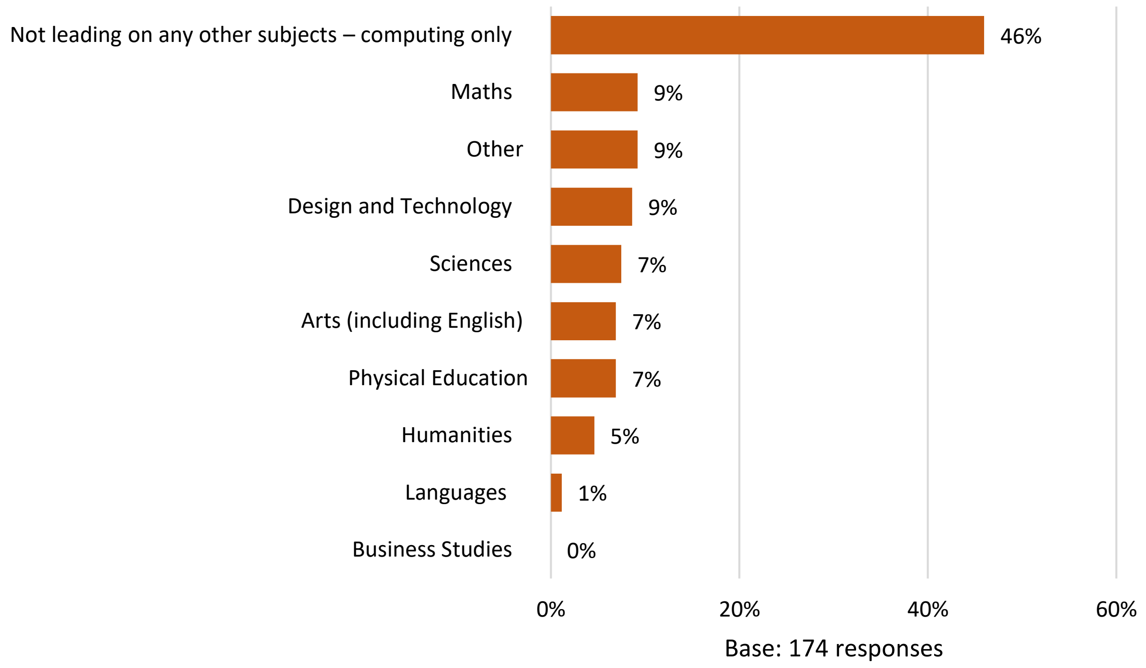
Table 16 Average FTE staff per school with at least some responsibility for computing education

Teaching responsibility	Primary schools	Secondary schools/colleges
Specialist computing teachers (i.e. computing is the only subject they teach)	0.5	2.0
Other teachers (i.e. general class teachers in primary schools and teachers of other subjects in secondary schools)	10.0	2.0
Non-teaching staff member (e.g. technician/maintenance staff)	1.0	2.0
Total	11.5 (of which 10.5 are teachers)	6 (of which 4 are teachers)

Drilling into these results in more detail, the majority of surveyed primary schools (84%) have a designated lead teacher of computing education. Of these lead teachers, more than half (54%) also have responsibility for leading at least one other subject area, most commonly Maths, Design and Technology and/or the Sciences. The mix of subject responsibilities among lead computing teaches in primary schools is shown in Figure 31[38].

[38] Responses to this question classified as 'Other' include: Head teacher, Music, PSHE, Religious Education, and Special Educational Needs.

Figure 31 Mix of subjects managed by lead computing teachers – primary schools

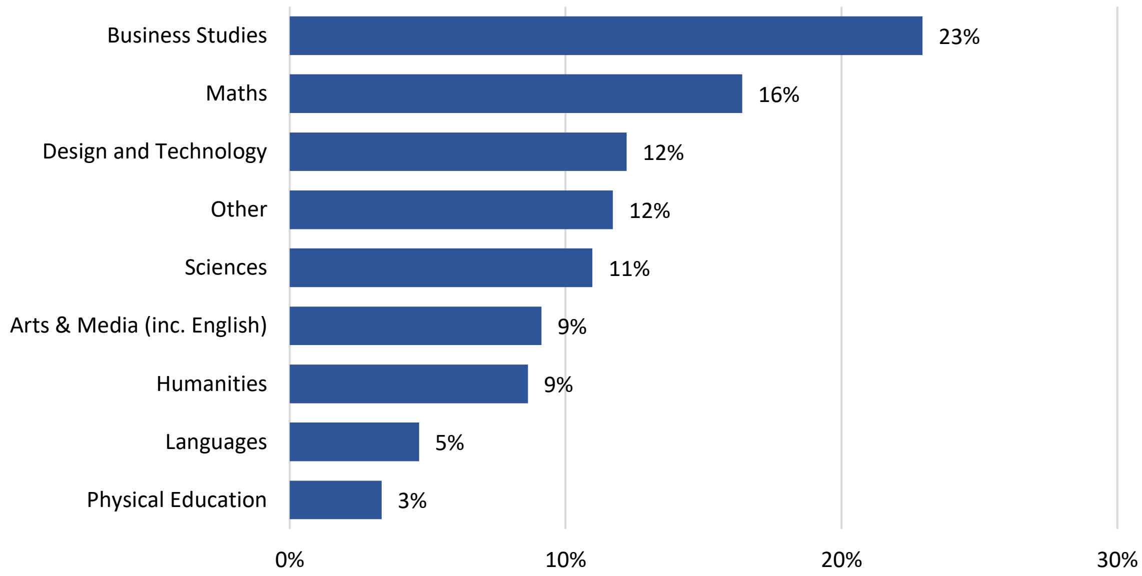


The majority of surveyed secondary schools (88%) have a dedicated department that specifically teaches computing education. In the remaining cases computing is taught as part of another faculty, most commonly combined with business studies, technology or maths.

Of the non-specialist computing teachers in secondary schools, the mix of other subjects taught is shown in Figure 32. The results suggest that schools are drawing on a range of other subject teachers to deliver computing, with the most common being Business Studies, Maths, and Design and Technology, but also including subjects as diverse as Humanities, Languages and PE[39].

[39] Responses to this question classified as 'Other' include: Citizenship, Economics, Health and Social Care, Law, PSHE, Psychology Travel and Tourism, as well as Special Educational Needs and cover for a primary school.

Figure 32 Mix of other subjects taught by computing teachers – secondary schools/colleges



Base: 811 responses

Many surveyed teachers and discussion group participants expressed concern about an apparent "expectation" or "inevitability" that computing is taught by non-specialists, particularly given how the curriculum in England was introduced so quickly. In some cases these views were given by teachers who were themselves relatively confident about teaching the subject, but appeared to be making a wider observation about other teachers in their school. A number of ICT teachers made the point in the survey that they have struggled to get to grips with the new curriculum.

In Newcastle it was mentioned that students in Year 9 (preparing to make their GCSE choices) risk being put off taking the GCSE by non-specialist teachers who don't have the same level of enthusiasm and passion as subject specialists.

"We've had teachers in tears because they couldn't grasp the basics of what the kids are supposed to be learning in primary school."

Computing teacher, Secondary school

5.3 Investment

5.3.1 Budget allocated to computing

Surveyed secondary schools/colleges were asked to provide their total budget allocated to computing education in the 2015/16 academic year. Using this information it is possible to determine the average available budget per student.

On the assumption that all students have the 'opportunity' to study some form of computing education (even where they may not be doing so), these figures provide at least some indication of how financial allocations compare between schools (including by 'type'), and across the nations.

These figures should be treated with some caution, since the calculations rely on the accuracy of financial data having been provided by schools, and base numbers are lower for institutions in Scotland, Wales and Northern Ireland. The figures also do not take account of differences in the courses offered by schools (e.g. how costs may differ between computer science versus ICT).

The results (Table 17) reveal that the average available computing budget across the UK in 2015/16 was £2,213.10 per institution and £2.26 per student. Whilst the typical amount per school is similar between independent and state-funded schools, it appears that this has to be stretched much further in state schools due to higher student numbers. This indicates that students in state schools may have more limited access to equipment and other computing resources.

As a point of comparison, in 2012 SCORE carried out research which identified budgets allocated to science subjects in schools across England. For the 2011/12 academic year, the average science budget per student was £8.81. This raises possible further questions for computing, notably:

- Does computing have to bid for, or 'tap into', budgets allocated to other subjects or umbrella faculties, such as science?

- Is computing under-funded compared with other subjects, particularly given its dependency on various hardware to be taught effectively?

Table 17 Average computing budgets (£) – secondary

Nation	Base	Avg. students per school	Avg. computing budget (£) per school	Avg. computing budget (£) per student	Min. budget (£) per student	Median	Max. budget (£) per student*
UK	**261**	**979**	**£2,213.10**	**£2.26**	**£0.00**	**£2.02**	**£54.05**
England	291	1,001	£2,272.79	£2.27	£0.00	£2.04	£54.05
Scotland	18	666	£1,372.00	£2.06	£0.47	£1.50	£10.94
Wales	8	991	£2,401.71	£2.42	£0.68	£2.58	£3.48
NI	7	802	£1,966.67	£2.45	£0.00	£2.45	£9.30
England – Independent schools only	46	565	£2,542.72	£4.50	£0.00	£4.26	£20.93
England – Other schools	215	1,095	£2,215.04	£2.02	£0.00	£1.82	£54.05

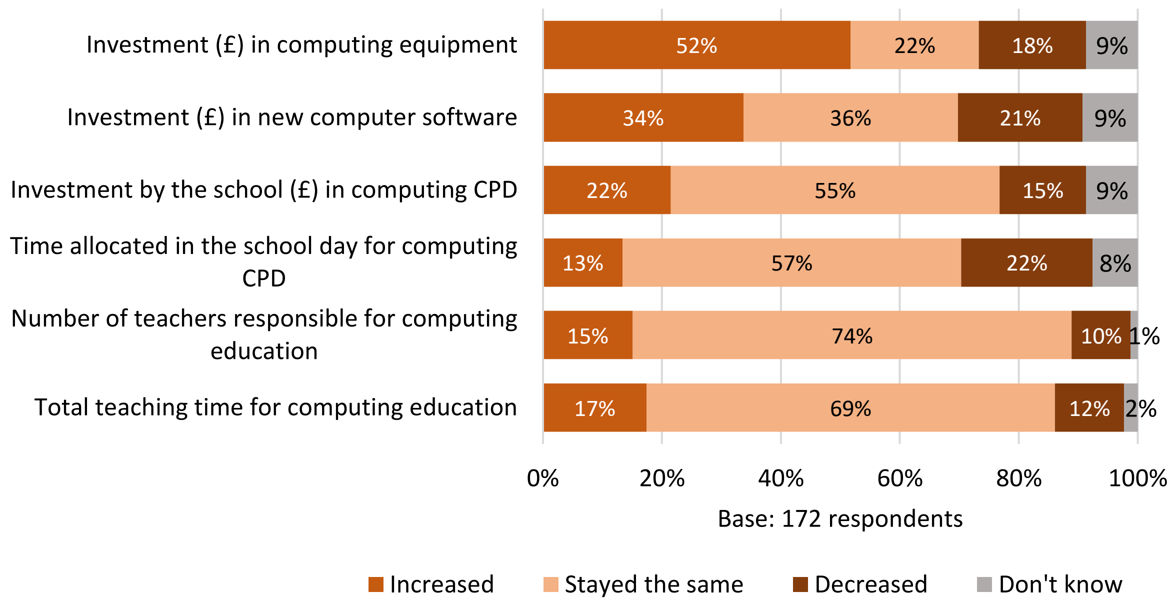
*9 schools returned a budget figure of £10.00 and above

5.3.2 Other investment trends

Between the 2013/14 and 2015/16 academic years (i.e. over a three-year period), schools were asked whether specific areas of investment in computing had increased, stayed the same, or decreased.

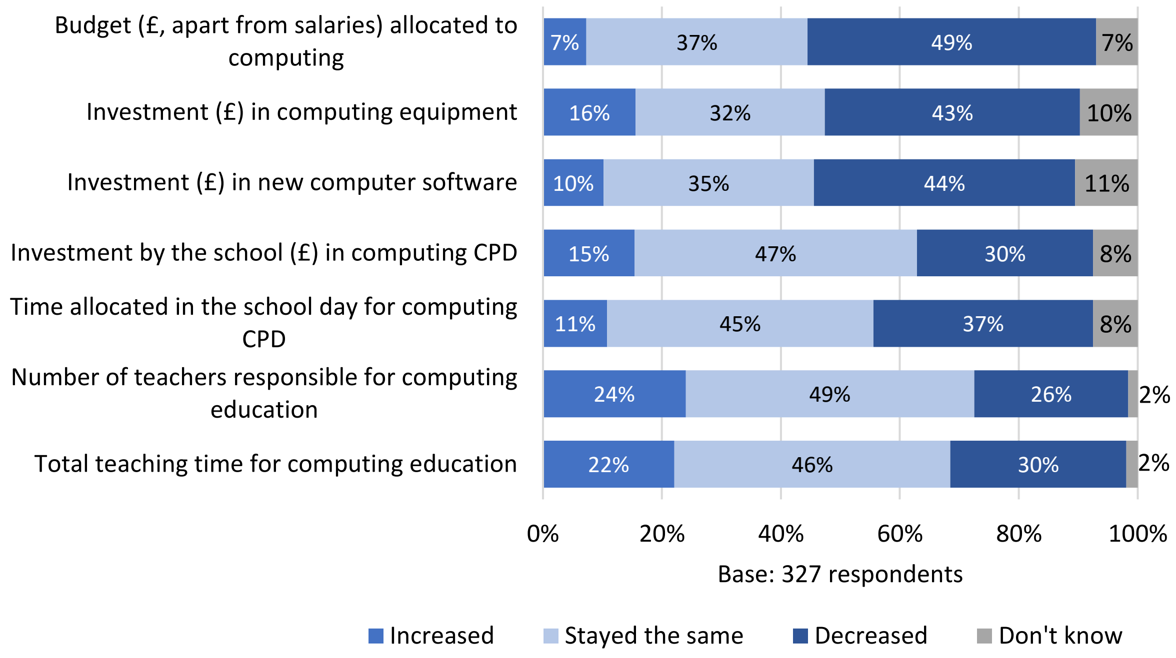
The results reveal mixed circumstances among primary and secondary schools. More than half of primary schools (52%) saw an increase in investment (£) for computing equipment over the past three years, but almost a fifth (18%) experienced a drop in funding. More than a fifth also experienced decreases in relation to investment (£) in computing software and time allocated in the school day for computing CPD (Figure 33).

Figure 33 Investment change between 2013/14 and 2015/16 – primary schools



In secondary schools, the results are even more disparate, with larger proportions of schools having experienced decreases than increases across all areas, particularly in relation to funding (Figure 34).

Figure 34 Investment change between 2013/14 and 2015/16 – secondary schools/colleges



"There's no training. The whole curriculum has changed and ICT teachers are teaching full days then going home to learn coding, alone and under pressure."

Head of ICT, Secondary school

5.4 Physical Capacity

5.4.1 Impact of Rising Student Numbers

Annual national increases in student numbers are likely to put increasing pressure on class sizes, teaching space and potentially the numbers of teachers who need to be available and equipped to deliver effective computing education in the future. In England for example, total primary school pupils rose by 11% (465,000) in the ten years from 2006 to 2016[40], which will have a knock-on impact on secondary schools in years to come.

[40] Department for Education (2016) *Schools, pupils and their characteristics, January 2016.* Table 2a.

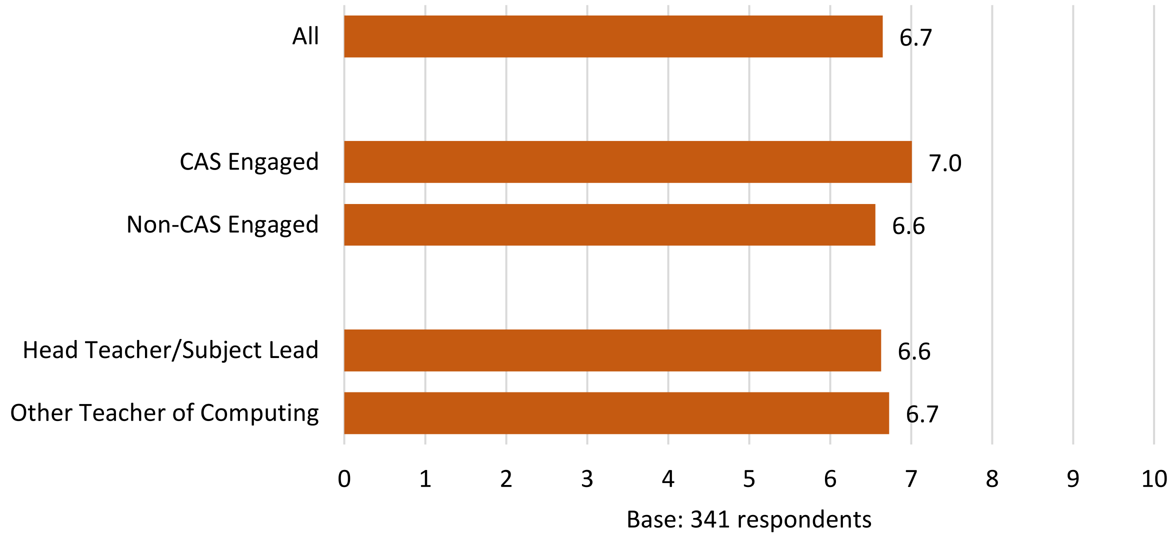
5.4.2 Suitability of Physical Resources

Computing education depends on a range of technologies such as computers, tablets, multimedia devices, microcontrollers and robotics, with examples including the BBC micro:bit[41], Raspberry Pi[42], Arduino[43] and Bee bot[44]. It also depends on teaching spaces that allow a blend of online and offline learning and good internet connectivity.

On a scale from 1 'very poor' to 10 'excellent', surveyed teachers were asked to rate the suitability of their equipment and other physical resources for enabling students to meet the requirements of the computing curriculum.

Average ratings are reasonably favourable, and very similar among primary schools (6.7 out of 10) and secondary schools/colleges (6.9 out of 10), although the distribution of ratings shows mixed perceptions/experiences. Specifically, 36% of primary teachers rated the suitability of physical resources at 8 or above, whilst a quarter (25%) gave a rating of 5 or below. In secondary schools, almost half of respondents (47%) rated physical resources at 8 or above, whilst just over a quarter (26%) gave a rating of 5 or below (Figures 35 to 38).

Figure 35 Perceived suitability of physical resources – primary schools (means)



[41] In March 2016, the BBC issued one million BBC micro:bit controllers free to year 7 students in England and Wales, S1 students in Scotland and year 8 students in Northern Ireland. The pocket-sized code-able computer allows young people to programme anything they want, from simple games to smart watches and even fitness trackers.
[42] The Raspberry Pi is a credit-card sized computer that plugs into a monitor and keyboard and can be used in electronics projects and to help learn programming
[43] The Arduino is a microcontroller for making things that can sense and control the physical world. It reads inputs like switches and sensors to create outputs, such as flashing lights, sounds and moving motors. The creative possibilities are extensive, for example it could be used to build an electric toothbrush or a 3D printer.
[44] A bee bot is a programmable floor robot in the shape of a bee. It has a simple layout of function button (forward, rotate left, rotate right, stop etc.) teaching control, directional language and programming to younger children.

Figure 36 Perceived suitability of physical resources – primary schools (rating distribution)

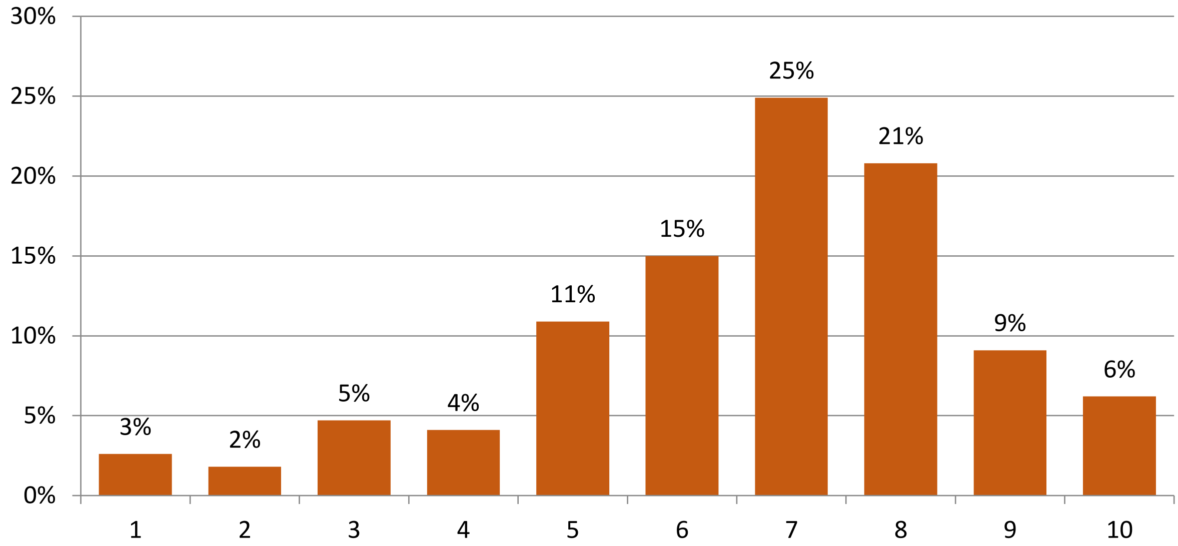


Figure 37 Perceived suitability of physical resources – secondary schools/colleges (means)

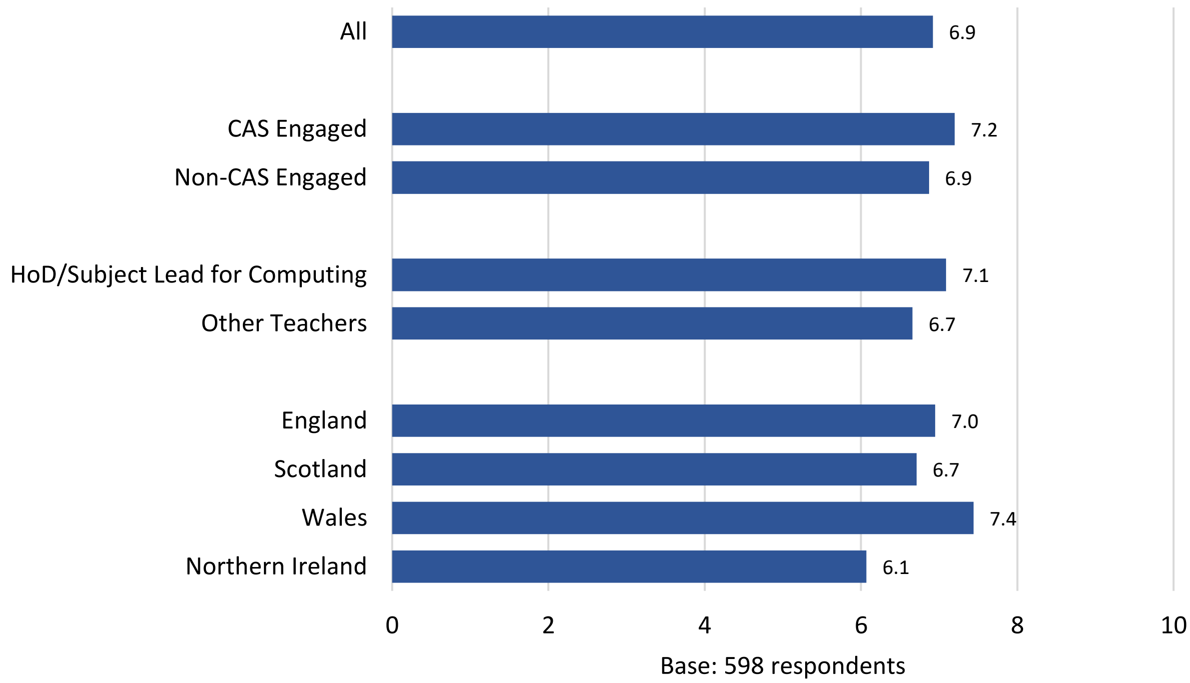
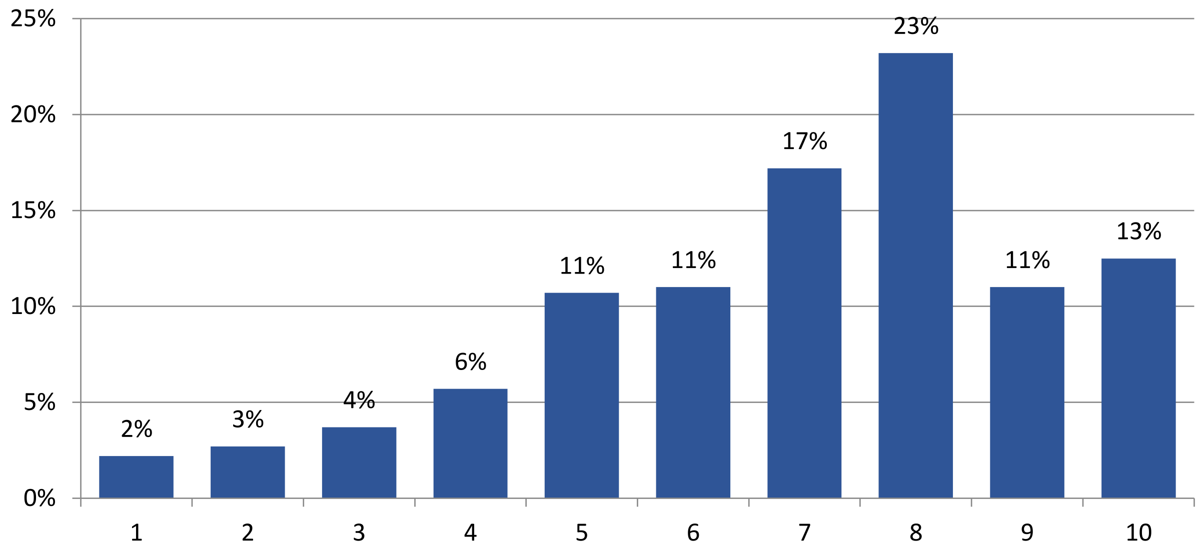


Figure 38 Perceived suitability of physical resources – secondary schools/colleges (rating distribution)



Teachers providing higher ratings in response to this question described how they have been able to make the necessary financial investments in equipment so that these can be accessed easily by all students who need them. Examples include desktop computers, laptops, netbooks, iPads, green screens, Office 365 software, Raspberry Pis, bee bots, Lego Mindstorms, free apps and video cameras. Some of these schools also mentioned having fast internet connectivity and cloud-based servers to crate 'virtual classrooms' (such as Skooler) for more efficient sharing of electronic teaching materials between teachers and students.

"Room layouts needed to change as there has been a pedagogical shift and IT rooms were not designed for this. Computing students need access to computers, but they also need space for other types of unplugged activities and sometimes the computers are a distraction".

Head of Computing, Secondary School

Among those teachers providing the lowest ratings for the suitability of physical resources, their circumstances appear almost diametrically opposed to other schools. They refer to insufficient computing hardware for the number of students, old, slow and outdated equipment with poor batteries, out of date software, slow network and internet connectivity speeds, lack of computing suites and dedicated teaching space to enable the subject to be taught effectively, as well as insufficient or reducing budgets to invest in making improvements.

"We have just spent £20,000 on upgrading to a new server, £5,000 on getting Wi-Fi through fund raising, but we also need new hardware throughout the school (tablets, netbooks laptops etc.) but we have no financial resources to do this."

Head teacher, Primary School

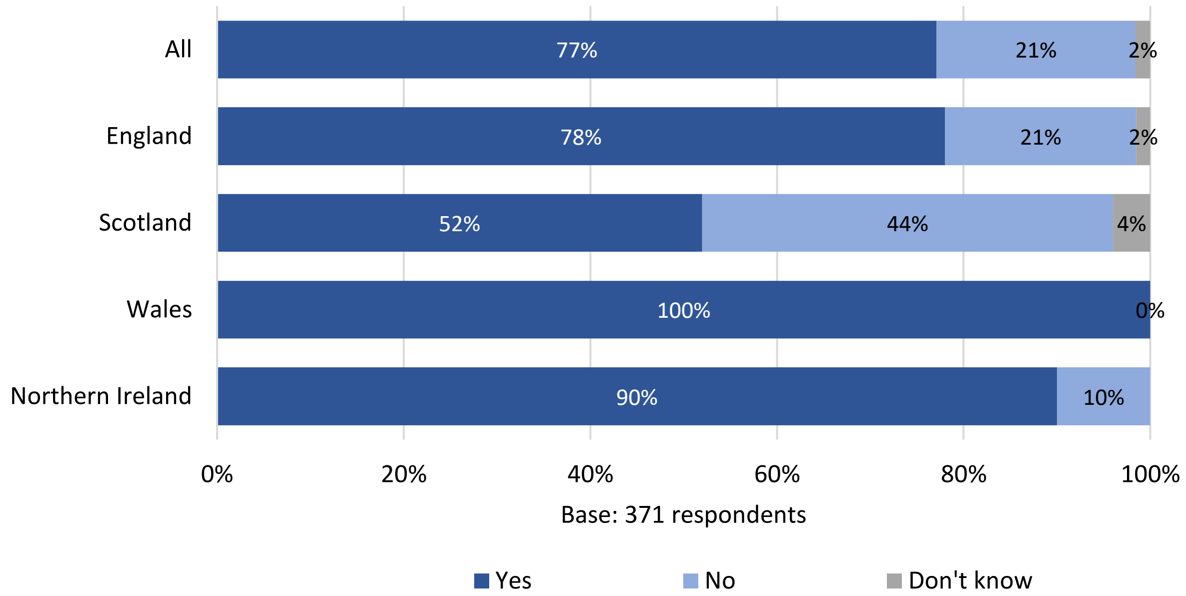
5.5 Extra-Curricular Computing Activities

Extra-curricular computing activities refers to those undertaken outside the normal course of study, such as informal activities at lunchtimes or after school.

Of the total student population in surveyed schools, 11% of primary pupils and 3% of secondary students participated in extra-curricular computing activities in 2015/16.

In the same year, extra-curricular computing activities were offered by more than half (62%) of surveyed primary schools and more than three quarters (77%) of secondary schools. National breakdowns are shown in Figure 39.

Figure 39 Proportion of schools offering extra-curricular computing – secondary schools/colleges



A breakdown of the types and frequencies of different types of extra-curricular computing activities are set out in Tables 18 and 19. The lists are ordered from most to least cited.

The most common types of activities are computing clubs (e.g. code clubs), in most cases held weekly. Other activities tend to take place less regularly and may be limited to particular year groups and specific groups of students, such as annual work taster visits to help students think about their GCSE subject choices. Examples from two of the case study schools include an annual year 9 trip to the offices of The Guardian newspaper in London to practice HTML coding, as well as the Sky Academy in Livingston.

Table 18 Frequency of extra-curricular computing activities – primary schools

Activity type (and Base respondents)	Daily/ twice weekly	Weekly	Twice monthly	Monthly	Every 2-3 months	Every 4-6 months	Annually
Computing clubs/code clubs (93)	10%	80%	-	2%	4%	2%	2%
Visits to other computing-related events (40)	-	-	-	-	5%	18%	78%
Cross-curricular projects (33)	-	6%	-	9%	18%	15%	52%
Guest talks in school (28)	-	-	-	-	4%	11%	86%
Entrants to computational thinking challenges (23)	-	4%	-	9%	-	4%	83%
Visits to industry (20)	-	-	-	-	-	5%	95%
Whole school 'super learning days' (20)	-	-	-	-	15%	5%	80%
University Ambassador Schemes (11)	9%	9%	-	9%	9%	9%	55%

Table 19 Frequency of extra-curricular computing activities – secondary schools/colleges

Activity type (and Base respondents)	Daily/ twice weekly	Weekly	Twice monthly	Monthly	Every 2-3 months	Every 4-6 months	Annually
Computing clubs/code clubs (259)	22%	71%	3%	1%	2%	1%	1%
Visits to other computing-related events/exhibitions (131)	-	-	-	-	14%	15%	72%
Entrants to computational thinking challenges (120)	1%	1%	1%	2%	5%	17%	74%
Visits to industry (120)	-	-	-	3%	8%	15%	74%
Guest talks in school (119)	-	-	2%	2%	8%	30%	58%
Cross-curricular projects (96)	1%	13%	2%	4%	15%	15%	51%
University Ambassador Schemes (64)	-	2%	-	-	13%	17%	69%
Whole school 'super learning days' (55)	-	-	-	-	6%	6%	89%

Based on the findings in this section, there are indications that extra-curricular computing opportunities in schools may be less prevalent than for other subjects such as science. A survey of 180 schools undertaken by Ofsted in 2013 found that extra-curricular science activities took place, to a greater or lesser degree, in every school inspected. The resulting report commented that, at their best, these activities complemented learning by extending students' experiences with extra experiments, projects, and visits to settings that used science. The latter allowed students a chance to meet professional scientists who explained their enthusiasm for science and gave students a sense of the fascinating breadth and depth of science in action. At a minimum, all schools were found to provided additional revision classes for students who had fallen short of expectations, or additional teaching time out of hours when school managers had not assigned sufficient timetabled lessons for a particular course[45].

5.6 Chapter Summary

Among surveyed schools, the most commonly reported amount of computing education undertaken by each pupil in England, Wales and Scotland[46] in 2015/16 was one hour per week. This ranges from zero hours (eight schools) to four hours (three schools). In secondary schools/colleges, the most common answer for each year of Key Stage 3 (S3/S4 in Scotland) was also one hour per week.

In primary schools, aspects of computing are delivered by general class teachers as part of the wider curriculum. Secondary schools and colleges appear to have a mix of specialist and non-specialist teachers delivering the subject. Figures for the average FTE staff per surveyed school who have at least some responsibility for delivering computing education are shown in Table 16.

The majority of surveyed secondary schools (88%) have a dedicated department that specifically teaches computing education. In the remaining cases computing is taught as part of another faculty, most commonly combined with business studies, technology or maths. Schools appear to be drawing on a range of other subject teachers to deliver computing, with the most common being Business Studies, Maths, and Design and Technology, but also including subjects as diverse as Humanities, Languages and PE.

Based on the results of the survey, the average available computing budget across the UK in 2015/16 was £2,213.10 per institution and £2.26 per student. Whilst the typical amount per school is similar between independent and state-funded schools, it appears that this has to be stretched much further in state schools due to higher student numbers. As a point of comparison, in 2012 SCORE carried out research which identified budgets allocated to science subjects in schools across England. For the 2011/12 academic year, the average science budget per student was £8.81.

Between the 2013/14 and 2015/16 academic years (i.e. over a three-year period), schools were asked whether specific areas of investment in computing (financial and non-financial), had increased, stayed the same, or decreased. The results reveal mixed circumstances in primary and secondary schools, with detailed results shown in Figures 33 and 34.

On a scale from 1 'very poor' to 10 'excellent', surveyed schools were asked to rate the suitability of their existing equipment and other physical resources for enabling students to meet the

[45] Ofsted (2013) *Maintaining curiosity: A survey into science education in schools*
[46] There are insufficient data to report timetabled hours for primary schools in Northern Ireland.

requirements of the computing curriculum. Average ratings are very similar among primary schools (6.7 out of 10) and secondary schools/colleges (6.9 out of 10). The distribution of ratings across the whole spectrum reveals mixed experiences. The minority of teachers providing the lowest ratings refer to insufficient computing hardware, old, slow and outdated equipment with poor batteries, out of date software, slow network and internet connectivity speeds, lack of computing suites and dedicated teaching space to enable the subject to be taught effectively, as well as insufficient or reducing budgets to invest in making improvements.

Finally, extra-curricular computing activities were offered by more than half (62%) of surveyed primary schools and more than three quarters of (77%) of secondary schools in 2015/16. The most common are computing clubs (e.g. code clubs), in most cases held weekly. Other activities tend to take place less regularly and may be limited to particular year groups and specific groups of students, such as annual work taster visits.

6. Widening Access

This section discusses the extent to which computing education appeals to girls and other groups, including less able students.

6.1 Girls in Computing

6.1.1 Gender Mix at GCSE and A level[47]

By way of national context, in 2015/16 girls accounted for just over half (51%) of total GCSE entrants (all subjects) in England.

Entrants to GCSE ICT courses (now being phased out) comprised a 41% share of female entrants in 2015/16. GCSE Computer Science courses by comparison have historically attracted a smaller proportion of girls, but there are signs that this is increasing (from 15% in 2013/14 to 20% in 2015/16).

At A level, ICT qualifications attracted a 34% share of female entrants in 2015/16. This compares with a 9% share for A level Computer Science, just a slight increase on 8% the year before.

The survey of secondary schools identified the gender mix of students working towards any form of non-compulsory computing qualification from Year 10 (England and Wales) and from level S4 (Scotland) in 2015/16. The results reveal that less than a third (29%) of Year 10 and S4 entrants were girls, along with a slightly lower proportion (20%) of Year 12 and S6 entrants[48].

6.1.2 Increasing Participation among Girls

According to teachers, computing is less appealing for girls than boys at secondary level, where parental and peer pressure, along with gender stereotyping, can influence their attitudes. The subject is still considered to be 'geeky', but some schools are working to try to inspire more girls to take computing at GCSE.

> *"I've been careful to avoid a focus on computer gaming, which can put girls off as this is considered to be a 'boys' domain."*
>
> *Computing teacher, Secondary school*

[47] Data for England in this section has been sourced from the Department for Education (January 2017) *SFR03/17: GCSE and equivalent results in England 2015/16 (Revised).* Data for Scotland have been sourced from SQA (December 2016) *Attainment Statistics.*

[48] Insufficient survey data available for Northern Ireland to report gender breakdowns.

Several participants observed that girls tend to be particularly strong on computing theory, often taking a comparatively more patient and logical approach to problem solving, but tend to be more likely to perceive programming errors as a 'failure', rather than as part of the process.

A small minority of primary schools (6%) and almost a fifth of secondary schools (18%) responding to the survey, reported having allocated additional resources or approaches intended to increase the participation of girls in extra-curricular computing activities.

Examples of activities include:

- Running bespoke extra-curricular activities,, such as Code Clubs for Girls (CC4G), Lego leagues, industry trips, inviting female speakers from the computing industry into schools, and hosting a 'women in engineering' day;

- Encouraging girls to consider taking computing as a subject option at GCSE where they might otherwise not do so, for example by using marketing materials that showcase women in technology- related jobs, and through one-to-one career talks; and

- Championing important historical female figures from the field of computing.

One of the case study secondary schools described how they make cross-curricula links to embed computer science in other subjects that girls at the school particularly enjoy, such as computer-based fashion design as part of Design and Technology, as well as in music composition. Another case study secondary school draws on its female computing staff as effective role models for girls looking to take the subject.

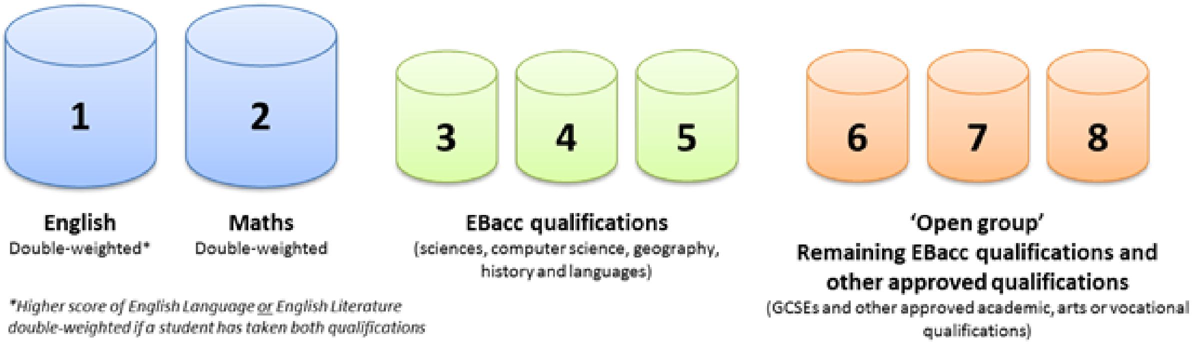
Discussions with primary age children as part of this research found some girls to be equally, if not even more excited about the subject than boys. As the new curriculum is so new at this age group, addressing the gender imbalance and stereotypical attitudes to computing and computer science is likely be a long term journey of cultural change.

6.2 Improving Access for All

In 2016 the Government introduced 'Progress 8' for measuring the performance of schools in England. This measure rewards schools for students who match or exceed their expected rate of progress from the end of Key Stage 2 in primary school, to the completion of their GCSEs. Subjects at GCSE are divided into three main categories or 'buckets' with different weightings, with the middle bucket including Computer Science (Figure 40).

Participants in the discussion groups were asked what kind of impact the Government's introduction of the 'Progress 8' performance measure has had on the development of computing in schools. The general consensus is that the measure has brought GCSE Computer Science "to the fore" for many schools, and will have contributed to increasing numbers of entrants.

Figure 40 Progress 8 measure in England



Wider concerns raised by teachers are that the academic nature of computing, particularly the higher order computational thinking skills and sensitivity of syntax, mean that some of the computing curriculum in secondary schools could be harder to access for students with certain learning difficulties. Having said that, a discussion group participant in Belfast gave an example of a primary school pupil who was autistic being "the best programmer in the school", indicating that computing can help to give confidence to certain groups of students who might struggle with other subject areas. A small minority of respondents also referred to computing being less likely to engage students from low income families who may not have computing equipment at home.

A number of suggestions were received through the survey and discussion groups for widening student access to computing. These include:

- Promoting and celebrating unique facets of the subject, notably the experimental elements and that making mistakes is a good thing rather than a point of failure;

- Tackling misconceptions among parents that their children are already good at computing where they are simply "users" of the technology;

- Linking computing education to the world of work, to inspire students from the earliest possible age (ideally at primary level) how they can use these skills later in life;

- Identifying ways of engaging students of all ability levels, for example by involving the most able students in activities such as lesson planning and helping others, whilst ensuring that computing lessons are fun and engaging for all students, including contexts that they can relate to and understand;

- Offering enrichment activities for a greater variety of inspiring content, such as lunchtime clubs and visits to industry (one of the case study secondary schools has involved A level

Computer Science students as facilitators of robot clubs to encourage wider involvement from the younger year groups); and

- Involving parents in computing lessons, particularly those who have jobs relating to computing.

6.3 Chapter Summary

Looking at total students embarking on non-compulsory computing-related qualifications in 2015/16 (Year 10/level S4), less than a third of students in surveyed secondary schools (29%) were girls. The proportion is slightly lower (20%) among Year 12/S6 entrants[49].

At secondary level, computing is considered to be less appealing for girls than boys due to factors such as parental and peer pressure, along with gender stereotyping. Some schools are working to inspire more girls to take computing at GCSE, for example via dedicated Code Clubs for girls.

Some concerns have been raised by surveyed teachers that the academic nature of computing, particularly the higher order computational thinking skills and sensitivity of syntax, mean that some aspects of the curriculum in secondary schools could be harder to access for students with certain learning difficulties.

Suggestions for widening access to computing for all students include promoting and celebrating unique facets of the subject (e.g. that making mistakes is a good thing rather than a point of failure); engaging with parents to tackle misconceptions about computing and also to involve them in learning and careers education where they have a computing job role; providing better linkages between computing education and the world of work; and identifying creative ways of engaging students of all ability levels in computing.

[49] Insufficient survey data available for Northern Ireland to report gender breakdowns.

7. Key Findings

1. **The new computing curriculum in England is generally welcomed by teachers participating in the research, although schools/colleges appear to be on a long term journey to developing and delivering effective learning. This is especially the case given that some schools have not yet fully 'transitioned' from offering GCSE/A level ICT to equivalent qualifications in Computer Science, and evidence that the subject is being delivered in some schools by a combination of specialist and non-specialist teachers.**

   Among those teachers who have at least some responsibility for delivering computing education, the extent of their understanding of computational thinking is varied, particularly in primary schools (Figures 2 and 3). In England, the survey has also identified mixed levels of favourability to the new computing curriculum, with secondary schools/college teachers especially dispersed in their views (Figures 6 and 7).

   Many teachers recognise that the types of computational thinking, coding and programing skills offered through a more computer-science focused curriculum are vital for the needs of industry in an increasingly digital world. There is also some caution and resistance, not only around a desire to ensure traditional ICT skills are not lost, but that more and better support, training and CPD is needed to ensure that all teachers responsible for delivering the subject have the knowledge, skills and resources to do so effectively (section 3.1.2). An emerging point from the discussion groups is that senior leaderships teams' buy-in to computing education is a vital lever to unlocking investment (both financial and non-financial) in developing schools' facilities, teaching knowledge and overall engagement with the subject (section 4.3.1).

   In accounting for current variations in teachers' levels of understanding, favourability and confidence, it is important to take into account the current period of 'transition' in computing qualifications at GCSE and A level, with ICT qualifications still being taught in some, but not all schools, ahead of being phased out by summer 2018 (section 2).

2. **There is evidence of a shortage of suitably skilled and qualified computing teachers, particularly in secondary schools, with the risk that this situation could worsen in the future if additional support is not put in place.**

   In secondary schools/colleges, there is evidence that computing education is being taught by specialist and non-specialist teachers, with some of the latter drawn from subjects as diverse as English and PE (section 5.2). This could affect the consistency and quality of learning given that the level of confidence among teachers holding their highest qualification in a non-computing discipline is lower than that of teachers holding their highest qualification in computer science – a statistically significant finding (Table 9).

Two scenarios could lead to an increase in the number of schools needing to recruit additional computing teachers in the future. Firstly, an 11% recorded increase in the number of primary school pupils in England over the past ten years[50] will have a knock on impact on secondary school numbers going forward (section 5.4.1). Secondly, those schools still holding on to GCSE ICT qualifications will need to have an alternative offer in place for Year 10 students from September 2017.

3. **Teachers believe that the new computing curriculum in England has been introduced with insufficient guidance around whom would teach the subject and how training, CPD and other guidance for teachers could take place.**

A small minority of surveyed primary teachers (7%) and just over a third of surveyed secondary school computing teachers (36%) hold a degree in computer science (section 3.3.1). Concerns have been raised through the open survey questions and discussion groups that teachers lack the time to invest in CPD and training. This is backed up by the most commonly reported number of CPD hours being zero among primary and secondary teachers who have at least some responsibility for teaching the subject (section 3.3.3), and evidence of falling levels of confidence among teachers through the year groups, especially in secondary schools (Figure 13).

To improve their confidence, teachers have asked for more courses and other forms of guidance so they can improve their subject knowledge and make the most of curriculum opportunities. Teachers call for more structured training courses that they can attend in the school day without having to travel a considerable distance, including content to develop their subject knowledge, programming know-how, awareness of available resources, and as a forum for sharing good practice and ideas.

Additionally, a range of teaching resources that have come to market in recent years from a range of publishers, makes it difficult for teachers to know which resources offer best value, and how to link these to the curriculum. This can lead to schools investing significant money on resource packs and they may not be aware how effective these are in relation to other materials (section 4.3.2).

4. **Variations in computing budgets and the suitability of physical resources and infrastructure in schools points to disparities in the opportunities for teaching and learning computing.**

Among surveyed secondary schools, the average computing budget per available student in the UK in 2015/16 was £2, (and ranged from nil where there was no computing teaching undertaken, to a maximum of £50). Furthermore, evidence suggests that independent schools in England are able to allocate more funds per student than state-funded schools. As a point of comparison, previous research carried out by SCORE identified that the average science budget per student was £9 in 2011/12 (section 5.3.1).

[50] Department for Education (2016) *Schools, pupils and their characteristics, January 2016.* Table 2a.

There are mixed scenarios as to whether financial investment, human resources and CPD time for computing have either increased, deceased or remained the same over the past three years, with more secondary schools reporting investment decreases than increases (section 5.3.2). Schools' ratings of the suitability of existing physical resources also reveal mixed experiences and span the full scale from 1 'very poor' to 1o 'excellent' (Figures 34 and 35). While some schools described having sufficient amounts of high quality equipment such as laptops, tablets and robotics, others reported that they don't have enough or that their equipment is old, not in good working order, and generally unfit to give students the best possible learning opportunities (section 5.4.2).

5. **Following its introduction, some teachers remain concerned the new computing curriculum in England risks placing too much emphasis on computer science at the expense of ICT and digital literacy being marginalised.**

   The content of the new computing curriculum and GCSE/A level Computer Science specifications has polarised opinions among schools. The majority are generally favourable to computer science, however, a minority are concerned that ICT skills – considered by respondents as vital for life and work – risk being side-lined in favour of computer science which they see as relatively niche (section 3.1.2)

6. **Variations in the abilities of computing students entering secondary school appears to be affected by current disparities in the level of understanding, favourability and confidence in computing education among feeder primary schools.**

   In the discussion groups and as part of the case study visits teachers described seeing mixed levels of prior exposure to computing education among students who enter their first year of secondary school. This is partly due to disparities in the amount and quality of computing education across feeder primary schools, with some first year students having had no prior experience at all. These inconsistencies make it more difficult for teachers to meet the needs of mixed ability classes, with the potential risk that less well-practised students get left behind, and the most able students are not sufficiently stretched.

   Conversely, where students have had strong exposure to computing education at primary level, their enthusiasm may be dampened where secondary schools are not adequately equipped for the subject (in terms of both knowledge and infrastructure) – section 3.2.1.

7. **Participation in computing education appears to be improving among girls, but some schools are being more proactive than others in widening access and broadening the appeal of the subject to different groups of learners.**

   National trends point to rising numbers of girls in GCSE and A level Computer Science courses, and there is evidence from the survey and discussion groups that some schools are undertaking activities and measures to better engage girls in computing, such as girls-only coding clubs.

Engaging girls in computing appears to be easier in primary schools, with the challenge being to keep them engaged as they get older and are subject to greater influence by parental and peer pressure (section 6.1.1).

More widely, there is a concern from teachers that computational thinking, as well as the added rigour of the recently reformed GCSE and A level qualifications in Computer Science, is too challenging for less able students, including those with learning difficulties. These teachers feel that the withdrawal of ICT means the less able students may not get any exposure to technology-related learning that they currently find accessible.

8. **Finally, there are some excellent examples from the discussion groups and case studies of transferrable best practice from schools that have successfully embedded computing education to date, including computer science.**

   Stand-out schools described having benefited from a supportive senior leadership team, strong investment in physical resources and new teaching materials, as well as a mutually supportive approach between teachers to professional development, knowledge and ideas sharing. These successful adopters of computing education, especially in England and Scotland, have taken a forward looking and creative approach to embrace the opportunities of the increased focus on computational thinking and computer science from their respective curricula.

   The most favourable and enthusiastic schools have identified that the complexities of the subject mean that teachers and students can learn from one another. Additionally, by tapping into national events, competitions and leagues, and by forging other external links, these schools are creating their own enhanced learning and extra-curricular activities.

   This research has obtained first hand evidence of students being engaged, enthused and delighted by what they are learning in computing. Examples include understanding that “getting something wrong” is OK and can move them one step closer to a sense of fulfilment when the project they’re working on eventually obeys the desired commands.

   By building partnerships with industry and academia, schools described how they have unlocked new learning opportunities for students, such as work taster days, sponsored competitions, guest talks, mentoring and to co-develop lesson ideas. The case studies have revealed positive examples of educational institutions at different levels working together, for example computer science university undergraduates supporting secondary schools, as well as secondary school students visiting primary schools to raise awareness around issues such as promoting online safety.

Recommendations are not included within this report. These have been developed separately by The Royal Society based on the findings from all three separately delivered Work Packages.

Appendices

A1 Sampling and Methodology

A1.1 Sampling

Based on the population of schools and colleges across the UK, the online survey set out to achieve a target of 380 primary school responses and 370 secondary school responses. These targets were set in order to achieve good statistical reliability (whole UK) with a ±5% margin of error at the 95% confidence interval.

The total number of unique school/college responses is set out in Table 20 (primary) and Table 21 (secondary), below. The true number of survey responses (higher, and allowing for multiple teacher perspectives per school) is shown in Table 1 in the main section of this report.

The achieved margin of error on a whole UK level is ±5.4% (primary) and 4.0% (secondary, including colleges). The margins of error for individual nations are higher, therefore cross-tabulations using nation or other criteria within this report should be treated with caution. The margin of error per question may also be affected by variations in the base number of responses.

Table 20 Sampling – primary schools

Nation	Population of schools[51]	Nation Mix %	Representative target	Achieved – unique schools
England	16,778	80%	304	285
Scotland	2,031	10%	37	37
Wales	1,330	6%	24	4
NI	814	4%	15	2
UK Total	**20,953**	**100%**	**380**	**329**

[51] Sources: England – Department for Education; Scotland – Scottish Government; Wales – Welsh Government; Northern Ireland – Department for Education Northern Ireland.

Table 21 Sampling – secondary schools/colleges

Nation	Population of schools[52]	Population of colleges[53]	Total	% mix	Rep. target	Achieved – unique institutions
England	5,341[54]	332	5,673	87%	350	490
Scotland	359	22	385	5%	24	44
Wales	207	15	222	3%	14	16
NI	202	6	208	3%	13	12
UK Total	**6,109**	**379**	**6,488**	**100%**	**400**	**562**

A1.2 Survey

Two questionnaires (aimed at primary and secondary/college teachers, respectively), were developed by Pye Tait Consulting in conjunction with The Royal Society and members of the Computing Education Project Advisory Group.

In primary schools, one survey response was requested from either the Head teacher or subject lead for computing education, and in secondary schools one survey response from the Head of Department/subject-lead for computing education. Many school-wide questions were only asked of these job roles, therefore only one set of answers was required per institution.

Responses were also invited from all other teachers with responsibility for delivering computing education. By selecting this job role in the survey, respondents were presented with only the relevant sections of the survey which asked for data relevant to themselves, including their own views and perceptions.

A definition of the generic term ‘computing education’ was made clear in the survey, i.e. that this referred to the curriculum in the respondent’s home nation. This included Computing (England), the Curriculum for Excellence: Technologies (Scotland), ICT (Wales), and Using ICT (Northern Ireland). Similarly, references to ‘computing teachers’ referred to all individuals with responsibility for teaching this area of the curriculum in the school.

The surveys were hosted online and were open for responses from 31st October 2016 to 23rd December 2016.

[52] Sources: England – Department for Education; Scotland – Scottish Government; Wales – Welsh Government; Northern Ireland – Department for Education Northern Ireland.
[53] Source: Association of Colleges (AoC).
[54] Includes state-funded schools, pupil referral units and independent schools.

A1.3 Minimising the risk of respondent self-selection

For the survey of schools, respondent self-selection refers to the risk of schools who are more favourable to computing (in particular computer science) being more predisposed to submit a response. Such a scenario could lead to a more favourable set of results than might reflect the teacher population, or risks certain issues or challenges faced by schools being downplayed.

Measures taken to minimise this risk were as follows:

- The start of the online survey contained the following prominently displayed message: *"This survey is aimed at all computing/ICT teachers in UK secondary schools/colleges. It is vital that we understand teachers' current levels of confidence, knowledge and skills for delivering computing education. This will ensure that the case for future support is based on a full and honest picture".*

- Survey invitation e-mails (including two further reminder emails) were sent to a random sample of schools across the UK (15,821 primary schools and 3,992 secondary schools).

- The survey was promoted through various organisations, such as via newsletters aimed at schools, as well as through social media, including Twitter, Facebook and LinkedIn.

- The survey questionnaire contained a number of open question boxes for respondents to explain their responses to rating scale questions, describe challenges faced, as well as what (if anything) could be improved in the future. These responses have been thoroughly analysed and a balanced account of the arguments presented in the report.

- The eight small discussion groups provided a further opportunity for teachers to discuss and debate computing education, with particular prompts around what works well and what could be better.

Consideration was given to weighting the survey results to be nationally representative in terms of computing teachers that hold their highest qualification in either computing or a different discipline. This was ultimately discounted since national data relating to teacher qualifications does not (at least, yet) fully reflect the change in emphasis from traditional ICT to a more computer science-based curriculum. It would therefore not have been appropriate to mirror the proportion of ICT teachers qualified in ICT within the weightings of this survey.

A1.4 Case Studies

As part of the survey, schools were asked if they would be willing to participate in a follow-up case study visit. The purpose of undertaking case study visits was to understand and be able to share best practice approaches to computing education in individual settings, as well as the journey undertaken to delivering the curriculum, including any obstacles overcome.

A total of eight case study visits were undertaken with schools. These were focused in England and Scotland only, reflecting the greater focus on computer science that has needed to be introduced in those countries in line with curriculum requirements in recent years.

The profile of participating case study schools included:

- England (2 x all-through schools, 2 x primary schools and 2 x secondary schools)
- Scotland (1 x primary school and 1 x secondary school)

Case study schools were based in different geographical regions and included a mix of state-funded and independent schools, including one all girls' secondary school.

The resulting written case studies have been produced separately to this report.

A1.5 Small Discussion Groups

A total of eight small discussion groups were facilitated by Pye Tait Consulting to explore aspects of the research in greater depth with primary and secondary/college participants. Five discussion groups were held in different cities in England (Birmingham, London, Manchester, Newcastle and Plymouth), as well as one each in Scotland (Edinburgh), Wales (Cardiff) and Northern Ireland (Belfast), respectively. The discussion groups attracted a combined total of 32 participants.

A2 Survey Respondent Profile

Tables 22-30 provide additional information about the characteristics of survey respondents in primary and secondary schools/colleges.

Table 22 Nation

Nation	Primary respondents	Secondary respondents
UK (All respondents)	**341**	**604**
England	297	526
Scotland	38	46
Wales	4	18
Northern Ireland	2	14

Table 23 Job Role

Job Role	Primary respondents	Secondary respondents
Head teacher or subject lead for computing education	175	373
Teacher with responsibility for delivering computing education	156	221
Other job role	10	10

Table 24 Subject of Highest Qualification (Teachers)

Subject of Highest Qualification (Teachers)	Primary respondents	Secondary respondents
Computer Science	27	256
Other Maths and Science Disciplines (not including Computer Science)	48	93
All Other Disciplines (not including Computer Science)	183	192

Table 25 CAS Engagement Status

CAS Engagement Status	Primary respondents	Secondary respondents
CAS engaged teachers	67	99
Non-CAS engaged teachers	274	505

Table 26 Length of time teaching

Job Role	Primary respondents	Secondary respondents
Less than 1 year	5	18
1-2 years	16	40
3-5 years	67	61
6-9 years	63	92
10+ years	187	390

Table 27 Mode of Employment

Mode of Employment	Primary	Secondary
Full time	291	539
Part time	50	56

Table 28 Region of England

Region	Primary respondents	Secondary respondents
East of England	33	41
East Midlands	18	29
London	39	71
North East	27	37
North West	24	70
South East	70	114
South West	30	72
West Midlands	27	49
Yorkshire and the Humber	29	43

Table 29 School Type (England) - Primary schools

School Type	Primary respondents
Community School (includes Special)	133
Academy (includes Converter/Sponsor-led/Special)	59
Voluntary Aided School	35
Other Independent School (includes Special)	25
Voluntary Controlled School	25
Other	5
Foundation School (includes Special)	13
Free School (includes Special)	2
Non-maintained Special School	0
Pupil Referral Unit	0
Secure Unit	0

- Scotland: 38 x Local Authority Schools;
- Wales: 4 x Maintained Community Schools;
- Northern Ireland: 2 x Primary Schools.

Table 30 School Type (England) - Secondary schools/colleges

School Type (England)	Secondary respondents
Academy (includes Converter/Sponsor-led/Special)	283
Community School (includes Special)	85
Other Independent School (includes Special)	69
Foundation School (includes Special)	21
Voluntary Aided School	15
Free School (includes Special)	12
Further Education	13
Other	4
Voluntary Controlled School	10
Sixth Form Centre	9
Pupil Referral Unit	3
Non-maintained Special School	1
University Technical College	1
Secure Unit	0
Special Post 16 Institution	0
Studio School	0

- Scotland: 41 x Local Authority Schools; 4 x Independent Schools; 1 x College;
- Wales: 15 x Maintained Community Schools; 2 x Independent Schools; 1 x Maintained – Voluntary Aided;
- Northern Ireland: 12 x Grammar Schools; 2 x Secondary Schools.

A3 NPD Data Table

This table should be read in conjunction with section 2.1.

Table 31 Computing-related qualifications and student entries (full NPD data for surveyed schools) [55]

Qualification	Category	Base survey respondents (not mutually exclusive)	% respondents	Total NPD entries	% mix of entries by category
BCS Level 2 ECDL Certificate in IT Application Skills (QCF)	Computer Appreciation/ Introduction	154	54%	9080	20%
OCR Level 1/2 Cambridge National Certificate		77	27%	3553	8%
BTEC Diploma Level 3		120	42%	1442	3%
Certificate for IT User Skills in Open Systems and Enterprise (QCF)		8	3%	598	1%
OCR Cambridge Technical Introductory Diploma at Level 3		34	12%	426	1%
BTEC Certificate Level 3		38	13%	337	1%
OCR Cambridge Technical Certificate at Level 3		28	10%	327	1%
BTEC L1/L2 First Certificate		3	1%	34	0%
Certificate in IT User Skills (Open Systems and Enterprise) (ITQ)		8	3%	27	0%
OCR Cambridge Technical Extended Diploma at Level 3		1	0%	15	0%
OCR Cambridge Technical Diploma at Level 3		3	1%	14	0%
BTEC Certificate Level 1		1	0%	5	0%
OCR Cambridge Technical Subsidiary Diploma at Level 3		1	0%	2	0%
Total		**N/A**	**N/A**	**15860**	**36%**
GCSE Full Course ICT	ICT	168	59%	8017	18%
GCE AS level ICT		100	35%	1638	4%
GCE A level ICT		86	30%	803	2%
Cambridge International Certificate Level 1/Level 2 ICT		11	4%	263	1%
Total		**N/A**	**N/A**	**10721**	**24%**

[55] Schools/colleges in England only 2015/16.

Qualification	Category	Base survey Respondents (not mutually exclusive)	% respondents	Total NPD entries	% mix of entries by category
GCSE Full Course Computer Studies/Computing	Computer Studies/ Computing	258	91%	7214	16%
GCE AS level Computer Studies/Computing		132	46%	1734	4%
GCE A level Computer Studies/Computing		108	38%	749	2%
Cambridge International Certificate Level 1/Level 2 Computer Studies/Computing		5	2%	98	0%
IBO Higher level component		1	0%	7	0%
IBO Higher level component		1	0%	4	0%
Total		**N/A**	**N/A**	**9806**	**22%**
CERT.IN DIG.APPS.LEVEL 2	Applied ICT	29	10%	1546	3%
Certificate In Digital Applications Level 2		29	10%	1546	3%
Edexcel Level 2 Certificate in Digital Applications		29	10%	1546	3%
Applied GCE AS ICT		53	19%	639	1%
Applied GCE Single ICT		39	14%	312	1%
Applied GCE AS Double ICT		1	0%	13	0%
Applied GCS Double ICT		1	0%	8	0%
Total		**N/A**	**N/A**	**5610**	**13%**
BTEC First Award L1/2 - Band C - P-D*	Computer Architecture/ Systems	30	11%	1368	3%
NCFE Level 2 Certificate in Computer Technology		1	0%	84	0%
Total		**N/A**	**N/A**	**1452**	**3%**
GCSE Full Course Office Technology	Office Technology	35	12%	1158	3%
Total		**N/A**	**N/A**	**1158**	**3%**
VRQ Level 3	Systems/ Network Management	1	0%	1	0%
Total		**N/A**	**N/A**	**1**	**0%**

A4 Reference Guide to School Ages and Years

The matrix below sets out the key stages, levels and year groups that operate in schools across each of the four UK nations.

The scope of this research did not include pupils in the 4-5 age bracket, for whom the computing curricula do not generally apply.

Table 32 School key stages, levels and years (UK)

Typical Age	Key Stage (England and Wales)	Year (England and Wales)	Level (Scotland)	Year (Scotland)	Year (Northern Ireland)
4-5	N/A	Reception	First	P1	Year 1
5-6	1	Year 1		P2	Year 2
6-7		Year 2		P3	Year 3
7-8	2	Year 3	Second	P4	Year 4
8-9		Year 4		P5	Year 5
9-10		Year 5		P6	Year 6
10-11		Year 6		P7	Year 7
11-12	3	Year 7	Third/Fourth	S1	Year 8
12-13		Year 8		S2	Year 9
13-14		Year 9		S3	Year 10
14-15	4	Year 10	Senior Phase	S4	Year 11
15-16		Year 11		S5	Year 12
16-17	5	Year 12		S6	Year 13
17-18		Year 13			Year 14

A5 Statistical Tests

The tables in this section represent the results of statistical tests carried out to support certain statements contained within the report.

Tables A to L each feature the variables that are the subjects of test, the type of test that was used and the results. Tests were carried out against results from both the primary school survey and the secondary school/colleges survey.

To begin with, detailed Chi Squared tests were carried out on the variables to investigate whether the data were independent (i.e. the variables differ from one another), or whether there was a relationship. Where the Chi Squared result is significant ($p < 0.05$), the null hypothesis, that there is no relationship between the variables, can be rejected. In certain cases, as is usual with such surveys, low-count cells have been encountered. This is entirely normal given that certain responses (for example a rating of 1 on a 1-10 rating scale) will inevitably attract low numbers of respondents. However, the reader is cautioned that, where there are high proportions of low-count cells, and taking into account the precise question under consideration, the resulting significance levels should be used with care.

Following on from the Chi Squared tests, where an ordinal scaled variable was analysed together with a nominal scaled variable, pair-wise Mann-Whitney U-Tests were performed. Where there were more than two groups of Independent Variables, a Kruskal Wallis test was carried out initially to investigate if there were any statistical differences between the variables. Further Mann Whitney U tests were then carried out if the Kruskal Wallis highlighted a significance, in order to establish further details concerning the significance.

The significance (p) level, was set to 0.05 for all tests. Results are described as significant where the p value is less than 0.05, and marginally significant when the p level is between 0.05 and 0.10. Results with $p > 0.10$ are interpreted as not significant. Where the Kruskal Wallis test was performed, the Bonferroni correction was applied altering the p level (stated in the tables).

A number of independent variables were chosen for the tests (Table A).

Table A: Independent variables and their characteristics for the tests

Variable name	Characteristics
CAS teacher engagement	Nominal scale with two options (CAS engaged, Non-CAS engaged)
Teacher type	Nominal scale with three options (Head of Department/Subject lead, Teacher, Other)
Highest qualification held (discipline)	Nominal scale with three options (Computer science, Other maths/science, All other disciplines)
Length of time in the teaching profession	Nominal scale with 5 options (Less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years)

For all dependent variables, the scales, answer options, and categories used for the analysis are shown in Table B.

Table B: Dependent variables and their characteristics for the tests

Variable name	Scale and range	Answer options	Categories used for analysis
How well did you **understand** the concept of computational thinking prior to completing this questionnaire?	Ordinal scale of 1 to 10.	From 1 “no understanding” to 10 “complete and full understanding”.	All are included
How **favourable** are you towards the new computing education curriculum in England?	Ordinal scale of 1 to 10 .	From 1 “not at all” to 10 “completely”.	All are included
How **confident** are you at delivering your current computing education curriculum at the following stages/levels?	Ordinal scale of 1 to 10 with 2 options for Primary (Key Stage 1, Key Stage 2) and 5 options for secondary (KS3, KS4, AS, A level, S2-4, S5-7).	From 1 “not at all confident” to 10 “extremely confident”.	All are included

Table C: PRIMARY SCHOOLS – Chi Squared results for all four independent variables and three dependent variables

Survey question/dependent variable	Statistical Test	Results	Cautionary notes
How well did you understand the concept of computational thinking prior to completing this questionnaire?	By CAS engagement (CAS, non-CAS).	P < 0.001; significant at the 1% level meaning there is a very strong relationship between the variables.	6 cells (30.0%) have expected count less than 5
	By teacher type (HOD/Subject lead, teacher, Other).	P = .150; non-significant at the level of 10% meaning there is evidence of no relationship between the variables.	15 cells (50.0%) have expected count less than 5
	By highest qualification (Computer Science, Other maths/science, All other disciplines).	There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables.	56.7% of cells have an expected value of less than 5
	By length of time in teaching profession (Less than 1 year, 1-2 years, 3-5years, 6-9 years, 10+ years).	P=0.533; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	32 cells (64.0%) have expected count less than 5
How favourable are you towards the new computing education curriculum in England?	By CAS engagement (CAS, non-CAS).	P < 0.01; significant at the 1% level meaning there is a very strong relationship between the variables.	9 cells (45.0%) have expected count less than 5
	By teacher type (HOD/Subject lead, teacher, Other).	P = 0.634; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	18 cells (60.0%) have expected count less than 5
	By highest qualification (Computer Science, Other maths/science, All other disciplines).	The test is inconclusive at the 10% level. There is evidence of no relationship.	50.0% of cells have an expected value of less than 5

	By length of time in teaching profession (Less than 1 year, 1-2 years, 3-5years, 6-9 years, 10+ years).	P= 0.346; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	34 cells (68.0%) have expected count less than 5
How confident are you at delivering your current computing education curriculum at the following stages/levels?	By CAS engagement (CAS, non-CAS).	Key Stage 1- P = .368; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. Key Stage 2 – P < 0.05; There is evidence of a relationship, significant at the 5% level meaning there is a strong relationship between the variables.	Key Stage 1 - 6 cells (30.0%) have expected count less than 5 Key Stage 2 - 6 cells (30.0%) have expected count less than 5
	By Teacher type (HOD/Subject lead, teacher, Other).	Key Stage 1 – P = .975; non-significant. The test is inconclusive. There is evidence of no relationship. Key Stage 2 – P = .987; non-significant. The test is inconclusive. There is evidence of no relationship.	Key Stage 1 - 16 cells (53.3%) have expected count less than 5 Key Stage 2 - 17 cells (56.7%) have expected count less than 5
	By highest qualification (Computer Science, Other maths/science, All other disciplines).	Key Stage 1 – The test is inconclusive at the 10% level. There is evidence of no relationship. Key Stage 2 – There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables.	Key Stage 1 - 63.3% of cells have an expected value of less than 5. Key Stage 2 - 66.7% of cells have an expected value of less than 5.
	By length of time in teaching profession (Less than 1 year, 1-2 years, 3-5years, 6-9 years, 10+ years).	Key Stage 1 – P = .814; non-significant; The test is inconclusive at the 10% level. There is evidence of no relationship. Key Stage 2 – P = .861; non-significant; The test is inconclusive at the 10% level. There is evidence of no relationship.	Key Stage 1 - 31 cells (62.0%) have expected count less than 5 Key Stage 2 - 32 cells (64.0%) have expected count less than 5

Table D: PRIMARY SCHOOLS – Differences by CAS engagement with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Mann Whitney U-Test, comparison of CAS engaged and non CAS engaged.	u = 5152.5; p < 0.001; significant
How favourable are you towards the new computing education curriculum in England?	Mann Whitney U-Test, comparison of CAS engaged and non CAS engaged.	u = 4695; p < 0.001; significant
How confident are you at delivering your current computing education curriculum at the following stages/levels?	Mann Whitney U-Test, comparison of CAS engaged and non CAS engaged.	KS1 - u = 5634; p = 0.021; significant KS2 – u = 4849.5; p < 0.001; significant

Table E: PRIMARY SCHOOLS – Differences by teacher type with respect to three survey questions/dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Kruskal Wallis Test, comparison of HOD/Subject lead, Teacher, Other.	P = .043; significant **(Bonferroni correction applied p = .016)**
	Mann Whitney U-Test, comparison of HOD/Subject lead and Teacher.	u = 13364.5; p = 0.879; non-significant
	Mann Whitney U-Test, comparison of Teacher and Other.	u = 405.5; p = .010; significant
	Mann Whitney U-Test, comparison of HOD/Subject lead and Other.	u = 485; p = .018; marginally significant
How favourable are you towards the new computing education curriculum in England?	Kruskal Wallis Test, comparison of HOD/Subject lead, Teacher, Other.	P = .143; non-significant

	Mann Whitney U-Test, comparison of HOD/Subject lead and Teacher.	U = 9550; p = .266; non-significant
How confident are you at delivering your current computing education curriculum at the following stages/levels?	Kruskal Wallis Test, comparison of HOD/Subject lead, Teacher, Other.	Key Stage 1 – P = .583; non-significant Key Stage 2 – P = .995; non-significant
	Mann Whitney U-Test, comparison of HOD/Subject lead and Teacher.	Key Stage 1 u = 9481.5; p = .686; non-significant Key Stage 2 u = 10238.5; p = .921; non-significant

Table F: PRIMARY SCHOOLS – Differences by highest qualification held with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Mann Whitney U-Test, comparison of computer science and NOT computer science.	U = 1282.5; p < 0.001; significant
	Mann Whitney U-Test, comparison of Other maths/science and NOT Other maths/science.	U = 1282.5; p = .730; non-significant
	Mann Whitney U-Test, comparison of All other disciplines and NO other disciplines.	U = 3703; p < 0.05; significant
How favourable are you towards the new computing education curriculum in England?	Mann Whitney U-Test, comparison of computer science and NOT computer science.	U = 1173.5; p = .001; significant
	Mann Whitney U-Test, comparison of Other maths/science and NOT Other maths/science.	U = 2885.5; p = .149; non-significant
	Mann Whitney U-Test, comparison of All other disciplines and NO other disciplines.	U = 3328; p = .226; non-significant

How confident are you at delivering your current computing education curriculum at the following stages/levels?	Mann Whitney U-Test, comparison of computer science and NOT computer science.	Key Stage 1 – u = 1348; $p < 0.05$; significant Key Stage 2 – u = 733.5; $p < 0.001$; significant
	Mann Whitney U-Test, comparison of Other maths/science and NOT Other maths/science.	Key Stage 1 – u = 2882.5; p = .253; non-significant Key Stage 2 – u = 3232; p = .620; non-significant
	Mann Whitney U-Test, comparison of All other disciplines and NO other disciplines.	Key Stage 1 – u = 2721.5; $p < 0.05$; significant Key Stage 2 – u = 2749.5; $p < 0.05$; significant

Table G: PRIMARY SCHOOLS – Differences by length of time in the profession with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Kruskal Wallis Test, comparison of less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years.	P = .975; non-significant
How favourable are you towards the new computing education curriculum in England?	Kruskal Wallis Test, comparison of less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years.	P = .869; non-significant
How confident are you at delivering your current computing education curriculum at the following stages/levels?	Kruskal Wallis Test, comparison of less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years.	KS1 = .292; non-significant KS2 = .568; non-significant

Table H: SECONDARY SCHOOLS – Chi Squared results for by all four independent variables and three dependent variables

Survey question/dependent variable	Statistical Test	Results	Cautionary notes
How well did you understand the concept of computational thinking prior to completing this questionnaire?	By CAS engagement (CAS, non-CAS).	P = .174; non-significant at the level of 10% meaning there is evidence of no relationship between the variables.	5 cells (25.0%) have expected count less than 5
	By teacher type (HOD/Subject lead, teacher, Other).	P = .1; non-significant at the level of 10% meaning there is evidence of no relationship between the variables.	16 cells (53.3%) have expected count less than 5
	By highest qualification (Computer Science, Other maths/science, All other disciplines).	There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables.	36.7% of cells have an expected value of less than 5
	By length of time in teaching profession (Less than 1 year, 1-2 years, 3-5years, 6-9 years, 10+ years).	P=0.163; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	28 cells (56.0%) have expected count less than 5
How favourable are you towards the new computing education curriculum in England?	By CAS engagement (CAS, non-CAS).	P = .089; Marginally significant meaning there is some relationship between the variables.	1 cells (5.0%) have expected count less than 5
	By teacher type (HOD/Subject lead, teacher, Other).	P < 0.05; significant. There is evidence of a relationship, significant at the 5% level meaning there is a strong relationship between the variables.	10 cells (33.3%) have expected count less than 5
	By highest qualification (Computer Science, Other maths/science, All other disciplines).	There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables.	13.3% of cells have an expected value of less than 5

	By length of time in teaching profession (Less than 1 year, 1-2 years, 3-5years, 6-9 years, 10+ years)	P= 0.143; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	24 cells (48.0%) have expected count less than 5
How confident are you at delivering your current computing education curriculum at the following stages/levels?	By CAS engagement (CAS, non-CAS).	Key Stage 3 - P = .542; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. Key Stage 4 – P = .306; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. AS – p = .824; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. A Level – p = .555; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. S1-S3 – p = .930; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. S4-S6 – p = .752; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	Key Stage 3 - 8 cells (40.0%) have expected count less than 5 Key Stage 4 - 3 cells (15.0%) have expected count less than 5 AS - 3 cells (15.0%) have expected count less than 5 A Level - 2 cells (10.0%) have expected count less than 5 S1-S3 - 10 cells (83.3%) have expected count less than 5 S4-S6 - 9 cells (75.0%) have expected count less than 5

	By teacher type (HOD/Subject lead, teacher, Other).	Key Stage 3- P < 0.05; significant. There is evidence of a relationship, significant at the 5% level meaning there is a strong relationship between the variables. Key Stage 4 – P < .001; significant. There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables. AS – p = .083; marginally significant. There is some evidence of a relationship. A Level – P < .0.5; significant. There is evidence of a relationship, significant at the 5% level meaning there is a very strong relationship between the variables. S1-S3 – P < .0.001; significant. There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables. S4-S6 – P < .0.001; significant. There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables.	Key Stage 3 - 17 cells (56.7%) have expected count less than 5 Key Stage 4 - 10 cells (33.3%) have expected count less than 5 AS - 10 cells (33.3%) have expected count less than 5 A Level - 10 cells (33.3%) have expected count less than 5 S1-S3 - 16 cells (88.9%) have expected count less than 5 S4-S6 - 15 cells (83.3%) have expected count less than 5

	By highest qualification (Computer Science, Other maths/science, All other disciplines).	Key Stage 3- There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables. Key Stage 4 – There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables. AS – There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables. A Level – There is evidence of a relationship, significant at the 1% level meaning there is a very strong relationship between the variables. S1-S3 - There is evidence of a relationship, significant at the 5% level meaning there is a strong relationship between the variables. S4-S6 – There is evidence of a relationship, significant at the 10% level meaning there is a relationship between the variables.	Key Stage 3 - 46.7% of cells have an expected value of less than 5 Key Stage 4 - 10.0% of cells have an expected value of less than 5. AS - 13.3% of cells have an expected value of less than 5 A Level - 10.0% of cells have an expected value of less than 5. S1-S3 - 53.3% of cells have an expected value of less than 5 S4-S6 - 50.0% of cells have an expected value of less than 5

	By length of time in teaching profession (Less than 1 year, 1-2 years, 3-5years, 6-9 years, 10+ years).	Key Stage 3 - P = .818; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. Key Stage 4 – P = .183; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. AS – $p < 0.05$; significant. There is evidence of a relationship, significant at the 5% level meaning there is a strong relationship between the variables. A Level – p = .067; marginally significant. There is some evidence of a relationship. S1-S3 – p = .953; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship. S4-S6 – p = .939; non-significant. The test is inconclusive at the 10% level. There is evidence of no relationship.	Key Stage 3 - 32 cells (64.0%) have expected count less than 5 Key Stage 4 - 26 cells (52.0%) have expected count less than 5 AS - 27 cells (54.0%) have expected count less than 5 A Level - 30 cells (60.0%) have expected count less than 5 S1-S3 - 28 cells (93.3%) have expected count less than 5 S4-S6 - 27 cells (90.0%) have expected count less than 5

Table I: SECONDARY SCHOOLS – Differences by CAS engagement with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Mann Whitney U-Test, comparison of CAS engaged and non CAS engaged.	u = 24115.5; p = 0.853; non- significant
How favourable are you towards the new computing education curriculum in England?	Mann Whitney U-Test, comparison of CAS engaged and non CAS engaged.	u = 18504.5; p = 0.220; non-significant
How confident are you at delivering your current computing education curriculum at the following stages/levels?	Mann Whitney U-Test, comparison of CAS engaged and non CAS engaged.	Key Stage 3 - u = 18705; p = 0.103; non-significant Key Stage 4 – u = 18342.5; p = 0.126; non-significant AS – u = 14620.5; p = .358; non-significant A Level – u = 14679.5, p = .428; non-significant S1-S3 – u = 26, p = .269; non-significant S4-S6 – u = 34, p = 606; non-significant

Table J: SECONDARY SCHOOLS – Differences by teacher type with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Kruskal Wallis Test, comparison of HOD/Subject lead, Teacher, Other.	P = .054; marginally significant **(Bonferroni correction applied p = .016)**
	Mann Whitney U-Test, comparison of HOD/Subject lead and Teacher.	u = 37124.5; p = 0.059; non-significant when Bonferroni correction is applied.
How favourable are you towards the new computing education curriculum in England?	Mann Whitney U-Test, comparison of HOD/Subject lead and Teacher.	U = 23698.5; p < 0.001; significant
How confident are you at delivering your current computing education curriculum at the following	Mann Whitney U-Test, comparison of HOD/Subject lead and Teacher.	Key Stage 3 - u = 28009.5; p < 0.05; significant Key Stage 4 - u = 22572; p < 0.001; significant

stages/levels?		AS - u = 20721; p = .001; significant A Level - u = 19349; p < 0.001; significant
		S1-S3 – u = 192; p = .127; non-significant S4-S6 – u = 215; p = .538; non-significant

Table K: SECONDARY SCHOOLS – Differences by highest qualification held with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Mann Whitney U-Test, comparison of computer science and NOT computer science.	U = 24503; p < 0.001; significant
	Mann Whitney U-Test, comparison of Other maths/science and NOT Other maths/science.	U = 19905.5; p = .644; non-significant
	Mann Whitney U-Test, comparison of All other disciplines and NO other disciplines.	U = 3703; p < 0.001; significant
How favourable are you towards the new computing education curriculum in England?	Mann Whitney U-Test, comparison of computer science and NOT computer science.	U = 19524.5; p < .001; significant
	Mann Whitney U-Test, comparison of Other maths/science and NOT Other maths/science.	U = 14131; p = .370; non-significant
	Mann Whitney U-Test, comparison of All other disciplines and NO other disciplines.	U = 17270; p < .001; significant
How confident are you at delivering your current computing education curriculum at the following stages/levels?	Mann Whitney U-Test, comparison of computer science and NOT computer science.	Key Stage 3 - u = 2020.5; p < .001; significant Key Stage 4 – u = 18791; p < .001; significant AS – u = 13571.5; p < .001; significant A Level – u = 13256; p < .001; significant
		S1-S3 – u = 152.5, p = .240; non-significant

		S4-S6 – u = 137.5, p = .263; non-significant
	Mann Whitney U-Test, comparison of Other maths/science and NOT Other maths/science.	KS3 - u = 14617; p = .208; non-significant KS4 – u = 15219.5; p = .463; non-significant AS – u = 10527; p = .147; non-significant A Level – u = 10775.5; p = .269; non-significant S1-S3 – u = 138, p = .837; non-significant S4-S6 – u = 116, p = .731; non-significant
		S1-S3 – u = 138, p = .837; non-significant S4-S6 – u = 116, p = .731; non-significant
	Mann Whitney U-Test, comparison of All other disciplines and NO other disciplines.	Key Stage 3 - u = 16838.5; p < .001; significant Key Stage 4 – u = 16154.5; p < .001; significant AS – u = 10099.5; p < .001; significant A Level – u = 10232.5; p < .001; significant S1-S3 – u = 34.5, p < .05; significant S4-S6 – u = 49.5, p = .213; non-significant
		S1-S3 – u = 34.5, p < .05; significant S4-S6 – u = 49.5, p = .213; non-significant

Table L: SECONDARY SCHOOLS – Differences by length of time in the profession with respect to three dependent variables

By survey question (variable)	Statistical Test	Results
How well did you understand the concept of computational thinking prior to completing this questionnaire?	Kruskal Wallis Test, comparison of less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years.	P = .102; non-significant
How favourable are you towards the new computing education curriculum in England?	Kruskal Wallis Test, comparison of less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years.	P = .011; significant **(applying Bonferroni correction p = .01)**
	Mann Whitney U-Test, comparison of less than 1 year and 1-2 years.	P < .045; non-significant with Bonferroni correction
	Mann Whitney U-Test, comparison of less than 1 year and 3-5 years.	P < .005; significant
	Mann Whitney U-Test, comparison of less than 1 year and 6-9 years.	P = .001; significant
	Mann Whitney U-Test, comparison of less than 1 year and 10+ years.	P = .001; significant
	Mann Whitney U-Test, comparison of 1-2 years and 3-5 years.	P = .215; non-significant
	Mann Whitney U-Test, comparison of 1-2 years and 6-9 years.	P = .105; non-significant
	Mann Whitney U-Test, comparison of 1-2 years and 10+ years.	P = .156; non-significant
	Mann Whitney U-Test, comparison of 3-5 years and 6-9 years.	P = .724; non- significant
	Mann Whitney U-Test, comparison of 3-5 years and 10+	P = .894; non-significant

	years.	
	Mann Whitney U-Test, comparison of 6-9 years and 10+ years.	P = .559; non-significant
How confident are you at delivering your current computing education curriculum at the following stages/levels?	Kruskal Wallis Test, comparison of less than 1 year, 1-2 years, 3-5 years, 6-9 years, 10+ years.	KS3 – p = .057; marginally significant KS4 – p = .066; marginally significant AS – p < .081; marginally significant A Level – p = .031; significant S1-S3 – p = .719; non-significant S4-S6 – p = .351; non-significant **(applying Bonferroni correction p = .01)**
	Mann Whitney U-Test, comparison of less than 1 year and 1-2 years.	Key Stage 3 – u = 223; p = .187; non-significant Key Stage 4 – u = 273; p = .432; non-significant AS – u = 278.5; p = 832; non-significant A Level – u = 253; p = .570; non-significant
	Mann Whitney U-Test, comparison of less than 1 year and 3-5 years.	Key Stage 3 – u = 337; p < .032; non-significant when applying Bonferroni correction Key Stage 4 – u = 448.5; p = .569; non-significant AS – u = 360; p = .403; non-significant A Level – u = 346.5; p = .354; non-significant
	Mann Whitney U-Test, comparison of less than 1 year and 6-9 years.	Key Stage 3 – u = 682.5; p = .889; non-significant Key Stage 4 – u = 565; p = .242; non-significant AS – u = 484.5; p = .204; non-significant A Level – u = 454.5; p = .128; non-significant
	Mann Whitney U-Test, comparison of less than 1 year and 10+ years.	Key Stage 3 – u = 2517.5; p = .303; non-significant Key Stage 4 – u = 2871.5; p = .931; non-significant AS – u = 2471; p = .975; non-significant A Level – u = 2465; p = .943; non-significant

	Mann Whitney U-Test, comparison of 1-2 years and 3-5 years.	Key Stage 3 – u = 910.5; p = 362; non-significant Key Stage 4 – u = 1035.5; p = .772; non-significant AS – u = 604; p = <.032; non-significant when applying Bonferroni correction A Level – u = 691.5; p = .331; non-significant
	Mann Whitney U-Test, comparison of 1-2 years and 6-9 years.	Key Stage 3 – u = 1206.5; p = .156; non-significant Key Stage 4 – u = 1397.5; p = .554; non-significant AS – u = 887.5; p = .027; non-significant when applying Bonferroni correction A Level – u = 923.5; p = .098; non-significant
	Mann Whitney U-Test, comparison of 1-2 years and 10+ years.	Key Stage 3 – u = 5637; p = .496; non-significant Key Stage 4 – u = 5464; p = .166; non-significant AS – u = 4796.5; p = .745; non-significant A Level – u = 4434; p = .431; non-significant
	Mann Whitney U-Test, comparison of 3-5 years and 6-9 years.	KS3 – u = 1782.5; p = .008; significant KS4 – u = 2162; p = .420; non-significant AS – u = 1628.5; p = .549; non-significant A Level – u = 1542; p = .444; non-significant
	Mann Whitney U-Test, comparison of 3-5 years and 10+ years.	Key Stage 3 – u = 8352; p = .033; non-significant when applying Bonferroni correction Key Stage 4 – u = 8851.5; p = .183; non-significant AS – u = 6233.5; p = .146; non-significant A Level –u = 5987.5; p = .096; non-significant
	Mann Whitney U-Test, comparison of 6-9 years and 10+ years.	Key Stage 3 – u = 12823; p = .168; non-significant Key Stage 4 – u = 11276.5; p = .008; significant AS – u = 8513.5; p = .018; marginally significant when applying Bonferroni correction A Level – u = 7973; p = .003; significant