Shadbolt Review of Computer Sciences Degree Accreditation and Graduate Employability

April 2016

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1 Foreword by Sir Nigel Shadbolt

A wealth of data points to the increasing role of the Internet and our computing infrastructure in the generation of economic wealth and social value in the UK. We need our citizens to be as computer literate as possible and for our specialist computer scientists to be at the heart of a continuing digital revolution. The UK has a long and proud tradition of innovation in computer science. Our Computer Sciences graduates are a vital part of the success of companies both large and small, organisations both public and private. The institutions that produce them are world class.

A UKCES Sector Insights report predicts that by 2022 some 518,000 additional workers will be needed to fill the roles available for the three highest skilled occupational groups in the digital arena. This is three times the number of Computer Sciences graduates produced in the past 10 years. Many employers talk of on-going skills shortages in these digital professions.

In this context, apparently high rates of unemployment amongst graduates of Computer Sciences and other STEM courses demanded an explanation. In response, Ministers launched two reviews: one led by Sir William Wakeham has examined STEM degree provision and graduate employability in general. My own review has focused on Computer Sciences degrees within English higher education institutions (HEIs) and may be a template for future more detailed exploration of other STEM disciplines. In both reviews the role of degree accreditation has been examined, so as to understand how it contributes to positive employment outcomes. However, while accreditation was a large element of the original review scope, the review broadened following analysis undertaken at the start of the process so as to better understand the full employment picture for our Computer Sciences graduates. Both reviews also recognise that higher education is not and should not be exclusively concerned with short term economic benefit. Universities enrich the intellectual well-being of the country by educating individuals in the life of the mind as well as preparing them for the world of work.

The methodology of the Shadbolt Review has comprised a number of elements. Firstly we have used Higher Education Statistics Agency (HESA) and other data to establish the facts of graduate employment as far as we can determine. For the purpose of the review and this report, Computer Sciences refers to all courses that fall within this subject grouping according to HESA. We have also sought to make data on employment outcomes widely available. The best way to have a balanced discussion in this area is to publish as much of the data as possible; this enables a wider conversation about what it says, how it should be interpreted and how good it is.

We have found that Computer Science and IT-related degrees are unusual in that almost every English HEI offers courses in them. In each of the last six years, more students have begun Computer Sciences courses than Physics, Chemistry and Mathematics combined. Unemployment among Computer Sciences graduates is currently running at a little over 10%. It has declined over the past few years – certainly from the levels of 2008-09 when it was around 18%. It displays wide regional variations and variations as against different types of HEI. There are differences associated with demographic background. The result is that some HEIs graduate cohorts with virtually no unemployment while others have levels of around one in four.

A second element of the review methodology was extensive consultation with stakeholders through workshops, focus groups and online surveys. This work revealed a number of consistent themes. One was the advantage conferred on those students who had employment experience either through formal placement schemes or other arrangements. It became clear that there is often a great deal of informal work experience that is not captured in the data that is returned, but which nevertheless makes a material difference.

Our consultations confirmed that the employment landscape for Computer Sciences graduates is extremely heterogeneous. IT and computing underpins so many aspects of business across all sectors and at all scales. Small and medium-sized enterprises (SMEs) and large corporations want different things from graduates. Some require hard technical skills while others prioritise broader soft skills such as effective communication skills.

The computer science landscape is very fast changing; from cyber security to cloud computing, mobile applications to big data analytics. A significant challenge to the HE sector is to provide agile and relevant content while securing a common core of essential knowledge.

There is a general recognition among those we have consulted that accreditation also needs to adapt. It is not well understood by either students or employers. A more flexible and lightweight approach is likely needed.

We have set out ten recommendations that we believe could improve the outcomes for our Computer Sciences graduates and identified who needs to be involved in implementing them. They should be addressed as a matter of urgency. The recommendations focus on the opportunity offered by improved data, what it is that graduates need so as to enter the marketplace with the best chances of success, how we understand the demand from different types of employer, how might this change in the future and how accreditation itself might change.

It is important that reforms and recommendations across education and within industry are coordinated and meet the needs of different types of employers as well as enabling graduates to enjoy a career that will span many more scientific and technological advances.

I am grateful to all of those who have given their time and expertise to the Review. In particular to the members of the Advisory Group who attended the various events organised as part of the Review and to those who provided written input. Finally, my thanks to the BIS and HEFCE teams who provided excellent support throughout the Review.

Nigel Shadbolt

2 Executive summary

2.1 In many areas, the performance of Computer Sciences graduates from English HEIs is outstanding, and the majority of graduates go on to fulfil important and rewarding jobs. The review recognises that there is much that is good about Computer Sciences as an academic discipline and its graduates. It points to and recognises the significant contribution that Computer Sciences graduates make to the UK economy and the increasing importance of computer science skills and knowledge across all areas of industry; graduates being employed, not only in hi-tech, specialist IT roles, but in a variety of different types and size of company. Many of these graduates go onto develop Computer Science through world class academic research. Many are the driving forces behind start-up businesses and are contributing to innovation in service delivery for companies both large and small. Although we have uncovered some challenges around employment outcomes for a number of graduates, it is significant that Computer Sciences as a discipline is not alone. A number of other STEM disciplines suffer with similar issues, as a parallel review undertaken by Sir William Wakeham has highlighted. There is much to celebrate for Computer Sciences. But the review recognises that there is still work to do to ensure its graduates are securing the outcomes that provide them with rewarding and fulfilling careers and to ensure that employers have access to the skills that they need.

2.2 This review has gathered evidence that indicates a mixed, and at times contradictory, picture of graduate employment outcomes and the potential contributing factors. The relatively high unemployment rates of Computer Sciences graduates which for the purposes of this review includes all courses within the Computer Sciences subject heading, is at odds with significant demand from employers and the needs of the burgeoning digital economy. The review considers evidence that the supply of Computer Sciences graduates, and the needs of employers appears in some way misaligned, uncovers a complex interrelationship between supply and demand, and puts forward recommendations for how this might be addressed.

2.3 The various degree programmes that fall under the broad discipline heading of Computer Sciences span a wide curriculum, and are taught at a variety of higher education (HE) providers and, like the industries that they serve, the discipline is not homogenous. The evidence suggests a complex picture of the interrelationship between the supply of graduates (and their individual characteristics) from HE, the varying nature of the demand for skills from employers, and the role played by the professional bodies in helping to bridge two sets of interests. The story is not straightforward, and there is no single headline figure or data set that comprehensively conveys the graduate employment situation.

2.4 As a headline discipline, Computer Sciences and its student population present particular features which appear to have a bearing on why its graduates suffer from higher unemployment rates (11.7% six months after graduation) relative to other STEM disciplines – Science, Technology, Engineering and Mathematics (8.4%). Computer Sciences includes the largest family of disciplines within STEM, with almost 2,000 courses available from 95 out of 130 HEIs in England. This includes courses in Computer Science, Information Technology and Software Engineering. Applications to study Computer Sciences appear to now be on the rise again after a big drop during the mid-2000s – it hit a peak of 41,000 entrants in 2002-03 compared with 19,000 entrants in 2014-15. The findings show a mixed picture: although more likely to be unemployed, compared to other STEM graduates, Computer Sciences graduates who are in employment are more likely to be in graduate level work and well paid.

2.5 A key finding is that the type of course that students enrol in matters: those studying sandwich courses enjoy the lowest levels of unemployment (6% sandwich vs 15% non-sandwich), the lowest levels of non-graduate level employment (6% sandwich vs 25% non-sandwich), and graduates from sandwich courses are twice as likely to be earning over £20,000 compared to those who did a standard degree. Graduates from integrated Masters programmes benefit from similar outcomes, but these courses are rare and tend to be concentrated in HEIs with the highest average UCAS tariff scores[1]. While each group of HEIs show a range of graduate employment outcomes, the very highest unemployment rates cluster in a small number of HEIs with the lowest average tariff scores. These HEIs also offer the lowest proportion of courses that include a formal sandwich year. But they teach the highest proportion of Computer Sciences students from under-represented groups (including Black and Minority Ethnic (BME) students, women, mature students and students from backgrounds where people have traditionally not participated in HE, known as low participation neighbourhoods, or LPNs)[2].

2.6 There are notable differences in the characteristics of Computer Sciences entrants compared to entrants in other STEM subjects which the review considers relevant to individual employment outcomes. There are significantly fewer women studying Computer Sciences (13% compared to 32% in STEM generally), although in other respects the discipline has been successful in attracting diverse entrants such as mature students and those from BME backgrounds. The growth in the proportion of entrants from backgrounds where people have traditionally not participated in higher education (LPNs) over the last decade is double that of other STEM subjects. Despite attracting diverse entrants there is evidence that positive outcomes are not evenly spread: unemployed graduates are more likely to be mature or from BME backgrounds. We also see high proportions of BME graduates in non-graduate level employment (31% BME compared to 17% white) which is more pronounced than in STEM generally (27% BME/24% white).

2.7 The evidence points to a strong supply of Computer Sciences graduates as vital for future innovation, productivity and growth; 'UK digital and creative…contributes almost nine per cent of total UK gross value added (GVA) and employs 2.1 million people'. A 2011 report, The Returns to Higher Education Qualifications, by London Economics for BIS[3] showed that graduates of Computer Sciences were among the subjects that provide the Exchequer with the most net benefits after Medicine and Dentistry, Law and Architecture.

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1 Further background to HEI groups by average UCAS tariff can be found in Chapter 4: Methodology, paragraph 4.9.

2 Information on POLAR classification groups and methodology to indicate HE participation among the young population: http://www.hefce.ac.uk/analysis/yp/POLAR/#d.en.91641

3 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32419/11-973-returns-to-higher-education-qualifications.pdf

2.8 We have gathered evidence that points to Computer Sciences graduates taking up employment in a wide range of different industries and in different geographical locations across the country. A quarter of Computer Sciences graduates are employed in London, with 10% having both studied and found employment there. The regional picture is also healthy, with notable strongholds of employment for Computer Sciences graduates in the South East, East Midlands, Manchester and Leeds. Graduates from sandwich courses enjoy the greatest spread of employment destinations, with 26% in London and the remainder employed across the country. This may be evidence that these students are more employable to a wider range of employers, or that linking up with regional employers during their course has led to an offer of permanent employment. The effect of student background on patterns of graduate mobility is starkest for Computer Sciences graduates from backgrounds where people have traditionally not participated in higher education (LPNs). These graduates are least likely to move to London for work (12% compared to 25% across all HE disciplines). This contrasts with the mobility of graduates from BME backgrounds, 43% of whom locate to London for work, with Birmingham the second most popular location for this group.

2.9 Encouragingly, we have observed that computer scientists continue to be in demand across a wide range of different industries and sectors, and that in terms of indicators relating to proportions of graduates in non-graduate roles and low salaries, graduate outcomes present very positive news about Computer Sciences. However, the evidence also points to enduring challenges. While many employers find that Computer Sciences graduates are well prepared for work, there continues to be a bloc of opinion that suggests that more could be done to improve graduates' skills and work readiness. However, a clear challenge is that employers are often divided on where the problem lies. There are a number of commonly reported issues, with graduates lacking work experience and commercial awareness, a lack of soft skills and insufficient technical knowledge among those most often quoted. Based on the review's survey data, employers who believed work experience to be 'critical' were only slightly more likely to offer work placements than employers who did not value it at all, indicating that more could be done by employers to offer the work experience they value so highly. There is evidence, too, that graduates are failing to recognise the benefits of work experience. In some circumstances unemployed graduates say that they failed, during their degree, to appreciate the importance of experience of the world of work and the soft skills that employers need.

2.10 We have found that employers disagree on what technical skills Computer Sciences students should be taught, although the balance of evidence points to support for HE providers teaching the fundamental principles of Computer Science, and encouraging and enabling students to learn and adapt to new technologies over their careers. This runs counter to an opposing school of thought that has been evident from some employers, that suggests that they want graduates with the skills that reflect the most up to date technological trends. The evidence we have seen points to the existence of a skills gap, but that there are significant challenges in being able to accurately measure and interpret the extent of the gap because of the varying nature of needs and expectations of employers.

2.11 Developing a clearer view of the skills that employers actually want is crucial, and there is a current lack of a coherent employer voice on what makes an employable Computer Sciences graduate. In addition to variations across industrial sectors and types of role, the needs of start-ups and SMEs should be taken into account as much as the requirements of large organisations. Small and micro businesses are increasingly at the heart of the digital revolution, and it is vital that the needs of these types of businesses are appropriately fed into the Computer Sciences graduate employment picture. Horizon-scanning for future skills requirements is therefore important, particularly given the fast-paced nature of computer science and the speed of technological advancement and innovation. This needs to be taken forward in collaboration with the HE sector to ensure that course design and content are appropriately informed and developed.

2.12 Engagement between business/industry and the HE sector is well-evidenced, and indicates a mutual desire for better and more meaningful collaboration. The review's evidence found that 95% of respondents agreed that engagement leads to enhanced employability, but that problems persist; 36% of employers believed that providers were not interested in engaging and 28% cited difficulties in making initial contact. Bridging the two worlds is part of the role of accrediting bodies, but evidence suggests that this role and systems of accreditation more broadly are poorly understood and valued by employers, students and HE providers.

2.13 Accreditation has been one of the focusses of the review, and we have been concerned specifically with the accreditation of degree programmes – the process by which degrees are assessed by professional bodies and accredited as delivering learning outcomes that meet specific standards. Although a minority see accreditation as a means to improve employability, employers do value accreditation which facilitates improvements in curriculum design and would like more differentiation between different types of course. For HE providers, the burden of existing accreditation systems is problematic, with many desiring process efficiencies and a streamlining of the system. While evidence indicates an acknowledgement of accreditation as a useful benchmark for standards and an indication of course content and quality, there is some way to go before this is considered a valuable tool for recruitment by employers or used by students to select a course in the Computer Sciences.

2.14 There is a mandate from employers and the HE sector to strengthen the current accreditation framework so that it is more focused on outcomes and links more closely with employability. It would benefit all stakeholders, including graduates, if employment outcomes, and employability, were to become a more central part of accrediting a degree programme. Accreditation should seek to support greater interaction between industry and HE, providing the mechanism to influence the design of degree programmes and an avenue for articulating the changing requirements of industry.

2.15 Understanding the dynamics that sit behind both the supply and demand sides is, therefore, not straightforward, and our understanding of the current landscape needs to improve. The data on graduate outcomes is limited in granularity and there is, therefore, only so much that we are able to infer from the data sets that we currently have access to. For example, little is known about the relative benefits of other types of work experience outside of the traditional sandwich placement and how powerful these could be in influencing positive outcomes. We have also been aware of anecdotal evidence within the computer science community that graduates from other STEM disciplines are helping to fill the gaps left by the apparent lack of suitably skilled Computer Sciences graduates. The scale, extent and reliability of this evidence is hard to quantify, but it is an important part of the picture and it would be helpful to understand more. It is also difficult, on the basis of the available information, to assess and predict demand from employers due to a lack of detail on the specific skills that employers are looking for and where in economic and geographic terms these skills are required.

2.16 We have been aware of wider discussions, which, although not within the remit of this review, are likely to have some relevance to the debate on Computer Sciences graduate employability. The recent report[4] by the Migration Advisory Committee (MAC) on the Tier 2 (skilled worker) visa route for non-European Economic Area (EEA) nationals raised a number of issues which have some relevance to computer science. This includes highlighting the potential for workers from non-EEA countries to migrate to the UK on temporary visas and take up IT-related roles that might otherwise be filled by Computer Sciences graduates. The Government response to the MAC report was published in March 2016; it accepted the majority of the MAC's recommendations, and is considering how to take forward the MAC's proposal for a review of skills in the IT sector. We welcome further exploration of these issues, including a review into skills shortages in the IT sector, the evidence base for which the findings of this report may help to inform.

2.17 We have found recurring themes which impact on graduate employment outcomes, but which are by no means unique to Computer Sciences as a discipline. While the majority of Computer Sciences graduates go into graduate level work in well paid roles the unemployment problem is worse among HEIs with low average tariff scores and disproportionately affects students with certain characteristics. Outcomes also appear to be worse among those who lack awareness of the importance of choosing the right course and the associated significance of developing soft skills alongside their technical knowledge. Work experience has a clear effect on evening out the impact of these themes, but much more needs to be done to expand participation and provision. Work experience opportunities, either formal or informal, are unlikely to be either feasible or desirable for every student, and there is evidence that there are opportunities for providers to convincingly convey these benefits as part of existing degree courses.

2.18 The review has uncovered a complex picture, and the explanation for the observed employment outcomes of Computer Sciences graduates cannot be located in any one place. The recommendations from this review will be relevant to all HE providers that offer some form of Computer Sciences provision in higher education and to all employers who require the skills of these graduates. What is clear is that the rapid pace of change in the digital economy will place increasing importance on the need to ensure that the supply and demand for Computer Sciences knowledge is appropriately aligned. This needs to be done in partnership between HE providers, employers, professional bodies and students to ensure that the UK has access to the robust pipeline of digital and IT skills and cutting edge research that it needs both now and in the future.

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[4] https://www.gov.uk/government/publications/migration-advisory-committee-mac-review-tier-2-migration

The Review's recommendations:

Recommendation 1 – Improving the data

Data on the supply of and demand for Computer Sciences graduates should be timely/up to date, accessible and comprehensive. The Council of Professors and Heads of Computing (CPHC), Association of Graduate Recruiters (AGR), Association of Graduate Careers Advisory Services (AGCAS), and Tech Partnership should devise a programme of work to improve the quality, richness and granularity, availability and accessibility of data. This should start by working with HESA to inform their Data Futures review and with Government on the future publication of linked educational and employment record datasets. This will help HE providers, employers, students, graduates and policy makers to better understand the graduate employment landscape and how this meets both the requirements of industry and an increasingly technology-driven economy now and in the future.

Recommendation 2 – Extending and promoting work experience

All Computer Sciences students should have opportunities to benefit from the skills and experience that are gained through formal sandwich year placements. This might be through increased provision of different types of work placement or finding ways to transfer the benefits of work placements directly to degree programmes. HE providers and employers should be creative and ambitious in developing mechanisms and routes for students to gain work experience, including summer internships and shorter placements. University Industry Advisory Boards should facilitate genuine engagement between HE and industry to ensure that these opportunities are relevant and provide real-world examples.

The National Centre for Universities and Business (NCUB), CPHC and National Union of Students (NUS) should work together to investigate the barriers (perceived or actual) that different groups of Computer Sciences students face in accessing and undertaking work experience that is unpaid or voluntary.

Recommendation 3 – Ensuring graduates' foundational knowledge and their ability to adapt

Computer Sciences course provision should recognise the fast pace of change in technology and seek to equip students with the ability to learn and upskill both throughout their programme, but also during their professional careers. However, HE providers, whether accredited or not, must also ensure that degree programmes continue to provide students with the core foundational knowledge and principles of computer science. This core should reference the Association of Computing Machinery (ACM)[5] curricula documents for the required body of knowledge.

5 https://www.acm.org/education/curricula-recommendations

Recommendation 4 – Improving graduates' softer and work readiness skills

HE providers and employers should consider how new models of provision, such as degree apprenticeships, may provide opportunities for students to develop work readiness skills alongside their academic studies. Employers should work with HE providers to support them in incorporating these opportunities into degree programmes. Employers should also recognise their role in providing training to graduates to enable them to develop professionally and to adapt their skills to the specific needs of a particular employer or industry.

Tech Partnership, the British Computer Society (BCS) and Institution for Engineering and Technology (IET) should work with employers and HE providers to accredit modules that provide students with both technical and soft skills and to ensure they are valued by students.

Recommendation 5 – Careers advice and visibility of graduate opportunities

The AGR and AGCAS should work with CPHC and Tech Partnership to develop a targeted campaign to provide Computer Sciences students with more specific detail on the types of roles and industries that require their skillsets. This should seek to identify role models from alumni and local industry contacts. This should be disseminated and led locally by careers services who should provide support to students in articulating their skills to potential employers. BCS and IET should work with AGR and AGCAS to develop a model for accrediting careers advice provision within Computer Sciences programmes.

Recommendation 6 – Developing a clearer view of the requirements of start-up technology companies

Start-up companies should be recognised as a distinct element of the employer landscape. The skills needs of start-ups should be specifically identified, and the role that start-up can play in providing work experience opportunities for students and inputting to Computer Sciences degree courses should be fully explored.

Tech City UK, the Open Data Institute, the Tech Partnership and NESTA should work together to act as a voice for start-up companies to enable them to interact effectively with HE providers, their students and graduates. This should reflect activity at the local, cluster level and input to enhanced data collection and analysis, outlined in Recommendation 1, to better understand the demands of start-ups.

Recommendation 7 – Developing a better understanding of, and supporting, SME requirements

Working through Tech Partnership and with Tech City UK, SMEs should be supported to ensure that their requirements for Computer Sciences graduate skills are captured and adequately reflected. In particular, further work is needed to support SMEs in providing work placements to Computer Sciences graduates.

Recommendation 8 – Horizon scanning for future demand for skills

HE providers, employers, accrediting and professional bodies should work together to horizon-scan for future skills requirements of Computer Sciences graduates. The CPHC, HEFCE, Tech Partnership, NESTA, BCS and the IET should work with, and build on, existing fora to identify future skills needs. The Group should use enhanced data outlined in Recommendation 1 and work together to develop a collaborative model with a clear remit and reporting line. The Group should deliver an annual report on the skills needs of Computer Sciences graduates, delivered through an annual summit/conference on Future Skills and with wider dissemination through local careers services.

Recommendation 9 – Academic accreditation of degree courses

BCS, IET and Tech Partnership should ensure that existing systems of degree course accreditation are flexible, agile, and enable HE providers to respond to changing demand and emerging technological trends and developments. Accreditation of courses should be focussed on outputs. Accrediting bodies should work to increase awareness and value of accreditation so that it is valued by HE providers, students and employers, and consider how their role can provide a forum for engagement between HE and employers.

Recommendation 10 – Engaging industry in accreditation

Employers, through employer groups, such as Tech Partnership, should engage more consistently with HE providers and BCS & IET to ensure accreditation is effective and reflects current industry demand.

3 Background

Aims and remit of the review

3.1 The aim of this review is to develop a clearer understanding of the reasons why graduates from Computer Sciences undergraduate degree courses[6] appear to suffer from poor employment outcomes relative to graduates from other STEM disciplines. As part of this investigation, the review considers the role of academic accreditation in maintaining or improving outcomes.

3.2 While the employment outcomes of postgraduate Computer Sciences students are not in the scope of this review, we reference the importance of continuing to ensure a pipeline of talent from undergraduate to postgraduate, including those graduates who go on to work in and support computer science departments and the research they undertake to advance the discipline. Similarly, as we are focussing on graduate 'outputs', we have not attempted to consider 'input' issues – such as increasing the numbers of certain types of students into Computer Sciences from school age. Rather, the review highlights particular concerns where we feel that they warrant attention.

3.3 Computer Sciences is not the only STEM discipline where graduates appear to suffer from poor employment outcomes. This review has run in parallel with the Wakeham Review of STEM degree provision and graduate employability, which recommends that further, in depth consideration of graduate employment outcomes is required for a range of STEM disciplines. The review, led by Sir William Wakeham, identifies a number of themes which impact graduate employment outcomes. Many of these themes correlate with those found as part of this review into Computer Sciences.

3.4 Both this review and the Wakeham Review recognise that there is a distinction between the terms 'employment' and 'employability'. And that, if a graduate is unemployed, this does not mean that they are unemployable. Employability is a fluid, complex and contentious concept. In its recent Occasional Paper[7], *Employability – Degrees of Value*, the Higher Education Policy Institute (HEPI) highlighted different definitions and views on employability and how it should be distinguished from employment. This included the difference between 'fixing' employment outcomes – that remain a snapshot in time – versus taking steps to 'enhance the students' long-term value and resilience in the workplace…[and]…their ability to achieve their best-fit career'. This review makes no attempt to define employability, or to use a particular definition as the basis on which to investigate Computer Sciences. Recognising that the review is founded on the basis of concerns around employment rates, we instead highlight any issues and themes concerning employability that are distinct from employment and which form an important part of discussions at certain points during the review.

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6 The review considers UK-domiciled students who graduated from first degree courses in Computer Sciences at publicly-funded English Higher Education Institutions (HEIs).

7 www.hepi.ac.uk/2015/12/10/employability-degrees-value/

3.5 Since the review was commissioned, there have been wider developments in the HE system. In November 2015 the Government published its Green Paper, *Fulfilling Our Potential: Teaching Excellence, Social Mobility and Student Choice*[8], which identifies graduate employment outcomes as an area that might inform measures on quality, outcomes and value for money in HE. The proposed Teaching Excellence Framework (TEF), which will take much of this thinking forward, is currently in development. This review does not make specific recommendations in response to the Government's proposal or the development of the TEF. However, the evidence gathered by this review may help to inform particular elements of the framework, where these relate to the complexities of measuring the outcomes of graduates based on their employment status.

Accreditation

3.6 One of the stated aims of this review was to explore the role of academic degree course accreditation and how, and if, this relates to graduate employment outcomes. However, while accreditation was a large element of the original review scope, the review broadened following analysis undertaken at the start of the process so as to better understand the full employment picture for our Computer Sciences graduates. The accreditation of degree programmes by professional, statutory and regulatory bodies (PSRBs) is one of the key mechanisms by which industry and the HE system interact; accredited programmes having demonstrated that they are meeting recognised standards, standards that in many cases are required for entry to particular professions.

3.7 In exploring the role played by accreditation, the review is concerned specifically with accreditation of academic degree programmes. This is an important point to make, given that accreditation can also cover the recognition of an individual who is seeking to become registered in the field of a particular profession. The accreditation of individuals for the purposes of professional registration has not formed part of the remit of this review.

3.8 At a high level, degree course accreditation is the process by which degrees are reviewed and judged as to whether they meet the published, defined standards set out by the relevant accrediting organisation. It provides students, employers and wider society with a mark of assurance that the degree programme in question meets the standards set out by the accrediting organisation. Accreditation can have a number of linked benefits, in that it can:

- Allow graduates to practise as a professional in their field
- Grant exemptions from all, or part, of professional examinations
- Provide some or all of the required knowledge for professional registration
- Provide entry to membership of a professional association/learned society
- Provide a public confirmation that HE providers are maintaining required standards and comparability with other degree programmes across the HE sector
- Assure employers that the graduates they recruit have met published standards
- Provide a benchmark against internationally respected standards

8 https://www.gov.uk/government/consultations/higher-education-teaching-excellence-social-mobility-and-student-choice

3.9 In many cases, employers and academics come together with the accrediting body to design the standards, and in many professions both are part of the team of reviewers that visit HE providers to assess their degree programmes. Accreditation can therefore provide employers with a strong voice in decisions about accredited degree status. For some disciplines, it can represent a key mechanism through which employers can influence the design of degree programmes and can provide an important way in which engagement between the HE sector and employers is facilitated.

3.10 In March 2011, the Higher Education Better Regulation Group (HEBRG) in collaboration with a number of partners produced a summary of the role that PSRBs play in HE, including how systems of accreditation contribute to provision. Further information on accreditation is, therefore, available in that report[9].

3.11 The academic accreditation of Computer Sciences degree programmes is delivered in the main by two professional bodies: the British Computer Society (BCS) and the Institution for Engineering and Technology (IET). The BCS accredits around 80 per cent of Computer Sciences degrees with a smaller number accredited by the IET. A small number of degree programmes are also accredited by Tech Partnership. Accreditation of Computer Sciences degrees does not constitute, and is not viewed as, a licence to practice for computer science professionals. Currently, IT and computer professionals are not required to have such a licence. Accreditation of degree programmes has, in the main, been used to enhance the professionalism of computer science as a discipline. Further detail on the accreditation of Computer Sciences degree programmes in available at Annex D.

3.12 In parallel to this review, the BCS has undertaken an examination[10] of its accreditation arrangements. This work is due to report following the publication of this review. Colleagues from the BCS, IET and Tech Partnership have formed part of the Advisory Group for the Shadbolt Review which has helped to complement both the review and the BCS-led project.

Why was this review commissioned?

3.13 This review was commissioned by Ministers from the Department for Business, Innovation and Skills (BIS) following the publication of the Government's Science and Innovation Strategy[11] in 2014. One of the key priorities set out by the Strategy was to ensure that the science and engineering talent coming through the UK's education system is appropriately developed and nurtured so that the UK has access to the skills and knowledge that it needs to drive economic growth and the development of a more innovative, productive and information-driven economy. To enable this, the Strategy identified the need to strengthen the supply of STEM graduates and to help to better align this supply with demand for STEM skills by encouraging employers and HE providers to work in partnership.

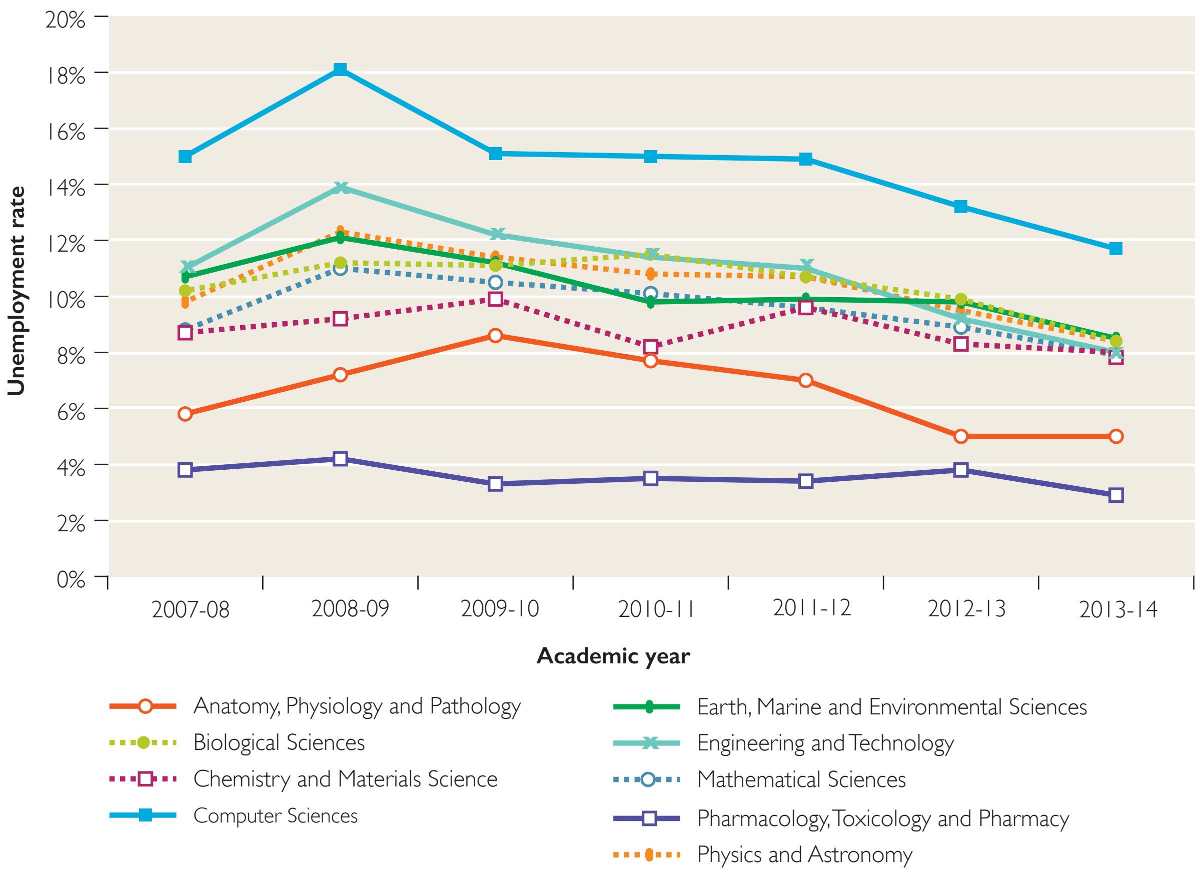
9 www.universitiesuk.ac.uk/highereducation/Documents/2011/HEBRG_ProfessionalBodies.pdf

10 http://academy.bcs.org/accreditationreview

11 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387780/PU1719_HMT_Science_.pdf

3.14 The Strategy builds on earlier work and themes in existing evidence which points to some concerning trends. In particular, that graduates from certain STEM degree disciplines appear to suffer from poorer employment outcomes relative to other disciplines. In addition, employers in some areas of the economy have previously reported that some STEM graduates need to be better prepared for work with skills that meet the needs of employers. A particular discipline of concern has been Computer Sciences, with a long and consistent pattern of unemployment among Computer Sciences graduates that is higher than the STEM average and higher than the unemployment rate across all subjects. According to data from the Higher Education Statistics Agency (HESA) on what graduates are doing six months after they graduate, 18.1 per cent of Computer Sciences students who graduated in 2008-09 were unemployed[12]. This compared to an unemployment rate across all STEM[13] subjects of 12.5 per cent and across all subjects of 10 per cent for the same cohort of 2008-09 graduates. Employment data for the latest cohort of Computer Sciences graduates where data is available shows that 11.7 per cent of students who graduated in 2013-14 were unemployed six months after graduation. While this is encouraging, it is still higher than the STEM average, of 8.4 per cent. Figure 1 shows how the unemployment rate for Computer Sciences graduates compares to graduates from other STEM subjects.

Figure 1 **Unemployment rates of UK-domiciled full-time first degree graduates from STEM subjects six months after leaving HE: graduates from publicly-funded English HEIs by STEM discipline, 2007-08 to 2013-14**



Source: HEFCE analysis of the HESA standard qualifications obtained population, 2007-08 to 2013-14. Graduates who subsequently provided a valid response to the Destination of Leavers from Higher Education (DLHE) survey six months after leaving HE.

12 As measured by valid responses to the Destinations of Leavers from Higher Education (DLHE) survey, conducted by HESA six months after a student has graduated from their degree course

13 STEM, as defined by HESA methodology, does not include Agriculture and Forestry.

3.15 This comparison with the outcomes of graduates from other STEM disciplines is important. While Computer Sciences graduates show high levels of unemployment, this trend is common across a number of other STEM disciplines. As highlighted later in the report, many other STEM disciplines suffer far worse employment outcomes than Computer Sciences graduates when we look at other employment indicators, including the proportion of graduates in non-graduate roles and the proportion earning low salaries. The evidence also needs to be considered in light of the significant contribution that Computer Sciences makes to the economy. A 2011 report, *The Returns to Higher Education Qualifications*, by London Economics for BIS[14] showed that graduates of Computer Sciences were among the subjects that provide the Exchequer with the most net benefits after Medicine and Dentistry, Law and Architecture. The net benefit to the Exchequer from Mathematical and Computer Sciences graduates is £118,034 (15.0 per cent). This is well above the average of £89,030 (10.8 per cent).

3.16 However, there is an enduring trend for higher than average unemployment rates among Computer Sciences graduates in spite of strong evidence of demand from employers. We need, therefore, to understand the reasons behind the apparent mismatch between supply and demand in greater depth. Together with this review into Computer Sciences at HE level, the UK Government is looking to address the challenges of a digital economy with a range of reforms at all education levels. This includes a new school computing curriculum, launched in September 2014, and revisions to Computer Sciences GCSE (introduced in 2015) and A-Level curricula (to be introduced in 2016). The Skills Funding Agency (SFA) has also recently published its report to consider publicly-funded digital skills qualifications[15]. In 2015, the Government also announced funding for an Institute of Coding: Centre for Digital Skills and Computer Science to enable training of the nation's next generation of coders, as part of the National Cyber Security Plan.

The demand – an overview of the value of Computer Sciences and trends in employer requirements for Computer Sciences graduates

3.17 The comparatively high unemployment rates among Computer Sciences graduates appear at odds with evidence of demand from employers for highly skilled employees and with the needs of a digital economy.

3.18 The importance of the digital economy has been highlighted by several reports. The Working Futures[16] report asserts that a range of professional and managerial professions will experience rapid growth between 2012 and 2022, including 'Science, research engineering and technology professionals and Business, media and public service professionals' (pg.82).

14 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32419/11-973-returns-to-higher-education-qualifications.pdf

15 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/499031/Review_of_Publicly_Funded_Digital_Skills_Qualifications_2016_FINAL.pdf

16 UKCES Working Futures 2012-2022 provides a comprehensive and detailed picture of the UK labour market, focusing on employment prospects for up to 75 industries, 369 occupations, 6 broad qualification levels, gender and employment status.

Using Working Futures data, the UK Commission for Employment and Skills (UKCES) report on challenges in the digital and creative sector predicts:

> "*that the digital and creative sector will need a total of 1.2 million new workers between 2012 and 2022. Just over three quarters of these workers will be in the three highest skilled occupational groups (managers, directors and senior officials; professionals; and associate professionals and technical occupations). … this suggests that the digital sub-sector will need 518,000 workers for roles in the three highest skilled occupational groups. However, over the last ten years only 164,000 individuals graduated from a first degree in computer science*" (pg.72-3).

3.19 This growth will also need to be supported by a population that has adequate digital qualifications at the basic and general as well as advanced and specialist level – a theme which is explored in more detail in the recently published *Review of publicly funded digital skills qualifications*[17], which states that in the 21st century '*almost every role will need an element of digital skills*' and that the digital economy '*is the economy*'.

3.20 The House of Lords report, *Make or Break: The UK's Digital Future*, notes that '*the digital sector alone was worth an estimated £105 billion in Gross Value Added to the UK in 2011*' and that '*digital technology is transforming much more than just one sector of the economy, the whole economy has become digitised*'. The contribution in certain areas of the economy has been unprecedented. Growth in online market places has been one such area, with internet retail volumes growing more than six times between 2003 to 2012, from £4.8 billion to £31.1 billion.

3.21 In their recent report *Tech Nation 2016*[18], Tech City UK and NESTA estimate that in 2014 the Gross Value Added (GVA) of the UK's Digital Technology Industries stood at £87 billion. According to the report, the digital technology economy[19] accounts for 1.56 million jobs, 41 per cent of these being located in traditional non-tech industries. The figures also suggest that the digital technology economy has almost three times faster job growth compared to the rest of the UK economy.

3.22 A number of technological trends have emerged in recent years which highlight further evidence of demand for highly skilled individuals. The UKCES Sector Insights report (2015)[20] suggests that these trends include: '*the growing importance of cyber security; the convergence of content across platforms; mobile and cloud computing; big data and analytics; the automation of routine tasks; new applications of social media; and new business models and collaborative platforms*'. These trends also have a part to play in determining future skills needs, not just for the digital and creative sectors, but for the wide variety of non-tech industries that rely on digital skills to support productivity.

17 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/499031/Review_of_Publicly_Funded_Digital_Skills_Qualifications_2016_FINAL.pdf

18 www.techcityuk.com/wp-content/uploads/2016/02/Tech-Nation-2016_FINAL-ONLINE-1.pdf?utm_content=buffer2e58f&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer

19 Covering all jobs in Digital Tech Industries and digital tech jobs within traditional non-tech industries

20 https://www.gov.uk/government/collections/ukces-sector-insights-reports-2015

3.23 *Tech Nation 2016* identifies 16 different sectors around which digital tech businesses are building their specialisms, with App and software development, Data management and analytics, Hardware, devices and open source hardware the three largest. New and emerging sub-sectors are also identified in the areas of games and cloud computing. Importantly, the crossover into traditional non-tech industries are also identified, with digital's contribution to technologies in the finance industry (Fintech) and healthcare (Healthtech) also cited as areas of growth. This demonstrates the cross-cutting nature of digital skills, and reinforces the notion that improved economic growth and productivity will also come from exploiting the opportunities to improve service delivery within both the public and private sectors and in sectors viewed traditionally as either technology or non-technology-based.

3.24 Data analytics – the discipline of interpreting large quantities of complex data to derive useful information – has regularly been highlighted as a key area within Computer Sciences and is the subject of recent work by NESTA and Universities UK (UUK). The report, *Analytic Britain – Securing the Right Skills for the Data driven Economy* (2015)[21], builds on NESTA's previous work, *Skills of the Datavores* (2015) and points to the increasing numbers of 'datavores' in the economy – businesses that make heavy use of data to drive and inform their business decisions. According to these reports, data-driven companies are over 10 per cent more productive than 'dataphobes' – firms that don't exploit the data available to them to its fullest use.

3.25 The importance to the economy and society of cutting edge research from Computer Sciences as an academic discipline should also be highlighted. A 2013 report jointly commissioned by the UK Computing Research Committee (UKCRC), CPHC and BCS, demonstrates the impact made by UK academic Computer Sciences research within the UK and worldwide over the period 2008 – 2013. The report, based on an assessment of twenty case studies submitted to the Research Excellence Framework (REF)[22] shows that over 80 per cent of the case studies had some form of economic impact. This includes spin-out businesses created by universities, software tools and techniques developed by research projects, and standard security and communication protocols in daily use by millions of users. According to the report, the annual revenue generated from those spin-outs was in excess of £170 million and employed nearly 1,900 people. It states that the additional sales revenues attributed to the academic research in industries such as aerospace, telecommunications, computing and energy was about £400 million. While the employment outcomes of postgraduate students is outside the scope of this review, many graduates from first degree programmes continue to further study (in 2013-14, 8 per cent of graduates from Computer Sciences were in further study or a combination of employment and further study, six months after graduation). For many, this constitutes the beginning of a path into academic research, the type of which is described in the impact report cited above. It is therefore important that the skills needs of our research base are also considered as part of the overall employment picture.

21 www.nesta.org.uk/sites/default/files/analytic_britain.pdf

22 www.ref.ac.uk/

3.26 Returning to Computer Sciences graduates from undergraduate degree programmes, the evidence shows that they go on to take up employment in a wide range of industries. While the majority of graduates entered roles in Information and Communication, a significant number were employed in Retail; Manufacturing, Education; Professional, Scientific and Technical, and Finance industries. In Chapter 5, we discuss the Standard Industrial Classifications (SICs) that are used to develop this type of analysis, and point to some of the challenges with the current classifications in terms of how they relate to job roles in the digital economy.

3.27 The UKCES report, *Reviewing the requirement for high level STEM skills* (2015)[23], estimates that high level STEM employment is widely distributed across the economy and is increasingly becoming service-sector based. Future job growth is expected to be focused on areas like Professional Services and Information and Communication – both of which are sectors where a large number of Computer Sciences graduates find employment. For the 'job family' of IT professionals, the UKCES identified the following occupations as having a strong requirement for high level STEM skills: IT specialist managers; IT project and programme managers; IT business analysts, architects and systems designers; Programmers and software development professionals; Web design and development professionals; Information technology and telecommunications professionals. It also found that the top three industry sectors by employment for IT professionals were Information and Communication (36 per cent); Professional Services (17 per cent); Financial Services (9 per cent).

3.28 Much evidence points to digital skills required outside of the digital and creative sectors. According to a CBI report, *Gateway to Growth*[24], an estimated 23 per cent of UK adults do not have basic digital skills. The CBI report notes that 61 per cent of businesses surveyed report weaknesses in IT skills competencies, a 4 per cent increase from the last survey in 2009. And UKCES found that '*the greatest recruitment challenges are currently experienced by those seeking workers with digital skills*', and that '*there are particular concerns about the ability of the education system to supply the quantity and quality of workers needed for digital roles*'[25]. The UK's future high level skills strategy needs to address these issues and ensure that the UK has access to a workforce that is equipped to meet the needs of a digital, and increasingly data-driven, society.

3.29 Evidence from the Association of Graduate Recruiters (AGR) supports the view that there are significant skills gaps in digital and IT. Its 2014 annual survey of employers found that, in 2013-14, 11 per cent of vacancies in those employers surveyed were for IT positions[26]. IT and Telecoms was also associated with the largest proportion of unfilled vacancies in 2013-14 (11.8 per cent). The Tech Partnership's *Employer Skills Survey 2015*[27] highlights that 72 per cent of large firms that employ tech specialists had experienced skills

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23 https://www.gov.uk/government/publications/high-level-stem-skills-requirements-in-the-uk-labour-market

24 www.cbi.org.uk/media/2807987/gateway-to-growth.pdf

25 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/432639/15.06.04._Digital_and_creative_SLMI_exec_summary.pdf

26 2014 Association of Graduate Recruiters survey:
https://www.agr.org.uk/Press-Releases/agr-summer-survey-graduate-job-vacancies-predicted-to-rise-by-17-#.VuqVoeKLQqM

27 https://www.thetechpartnership.com/globalassets/pdfs/research-2015/tec_employer_skill_survey_web.pdf

gaps in their workforce compared to 49 per cent of SMEs, and also points to particular gaps in skills relating to cyber security, mobile computing, big data analytics and cloud computing. Building on this, and looking across the whole economy, the UKCES 2013 Employer Perception Survey (EPS) found that of all vacancies (defined as an employer reporting they cannot fill a post due to a lack of sufficiently skilled applicants) 16 per cent were due to a lack of basic digital skills, and 22 per cent due to a lack of advanced IT or software skills. The EPS also looked at skills gaps within the existing workforce. Where there were skills gaps, 25 per cent of these related to basic digital skills, and 22 per cent to advanced IT or software skills. Finally, the EPS looked at future skills needs of the existing workforce. Where employers anticipated a need to upskill their staff within the next 12 months, 23 per cent expected this to cover basic digital skills, with 33 per cent looking to address advanced IT or software skills.

3.30 Significantly, this is not an issue that the UK alone is struggling with. These trends are mirrored across Europe. By 2020, more than 800,000 technology posts will be unfilled due to the skills gap, according to the European Schoolnet (EUN) Report, *Stimulating Interest in STEM Careers among Students in Europe: Supporting Career Choice and Giving a more Realistic View of STEM at Work*[28]. However, while Computer Sciences graduate numbers are steadily recovering in England, the rest of Europe is seeing a levelling off or, in some cases, a drop in its graduates, leading to concerns around mismatches between supply and demand. According to the EU's Directorate-General for Internal Policies' report *Encouraging STEM Studies for the Labour Market*[29], employers across Europe share a concern that graduates lacking the right attitude and aptitude, as well as experience of work, are the real barriers to graduates meeting employer demand.

3.31 In the US, the issue of the lack of Computer Sciences graduates is being tackled at the earliest stages of education. President Obama recently announced a 'Computer Sciences for All' initiative with over $4 billion of funding '*to empower all American students from kindergarten through high school to learn computer science and be equipped with the computational thinking skills they need to be creators in the digital economy*'[30]. The initiative seeks to ensure that the growing number of technology roles are able to be filled by qualified students. It notes that, last year, there were more than 600,000 high-paying tech jobs across the US that were unfilled, and by 2018, 51 percent of all STEM jobs are projected to be in computer science-related fields. The US is also seeking to increase participation among women, students from deprived backgrounds, and African-American and Latino students.

28 www.educationandemployers.org/wp-content/uploads/2014/06/joyce_-_stimulating_interest_in_stem_careers_among_students_in_europe.pdf

29 www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf

30 https://www.whitehouse.gov/blog/2016/01/30/computer-science-all

Supply – an overview of Computer Sciences provision at publicly-funded English HEIs

3.32 Computer Sciences is unusual among STEM disciplines in that it is taught at the large majority of HEIs. In academic year 2014-15, 95 of 130 publicly-funded English HEIs offered courses which sit under the broad heading of 'Computer Sciences' (including four institutions who only delivered Computer Sciences provision at postgraduate level). In comparison, undergraduate degrees in Physics are taught at 56 HEIs; 29 of these are 'high tariff'[31] universities. While the majority of students study degree courses with the title Computer Sciences or Information Systems, Computer Sciences includes courses in Artificial Intelligence and Software Engineering. Students can also study joint programmes, such as Computer Sciences and Mathematics. Annex F sets out a summary of the descriptions of the different courses falling within the headline Computer Sciences discipline according to HESA definitions.

3.33 Also of significance is the size and scale of Computer Sciences as an academic discipline. In each of the last six years, more students have begun a Computer Sciences undergraduate degree course than have started Physics, Chemistry and Mathematics combined. In 2014-15 there were 22,985 undergraduate entrants to Computer Sciences undergraduate degree programmes. This compares to, for example, 4,830 in Physics, 11,610 in Mechanical, Aero and Production Engineering, 10,215 in Mathematics and 5,315 in Chemistry and Materials Science.

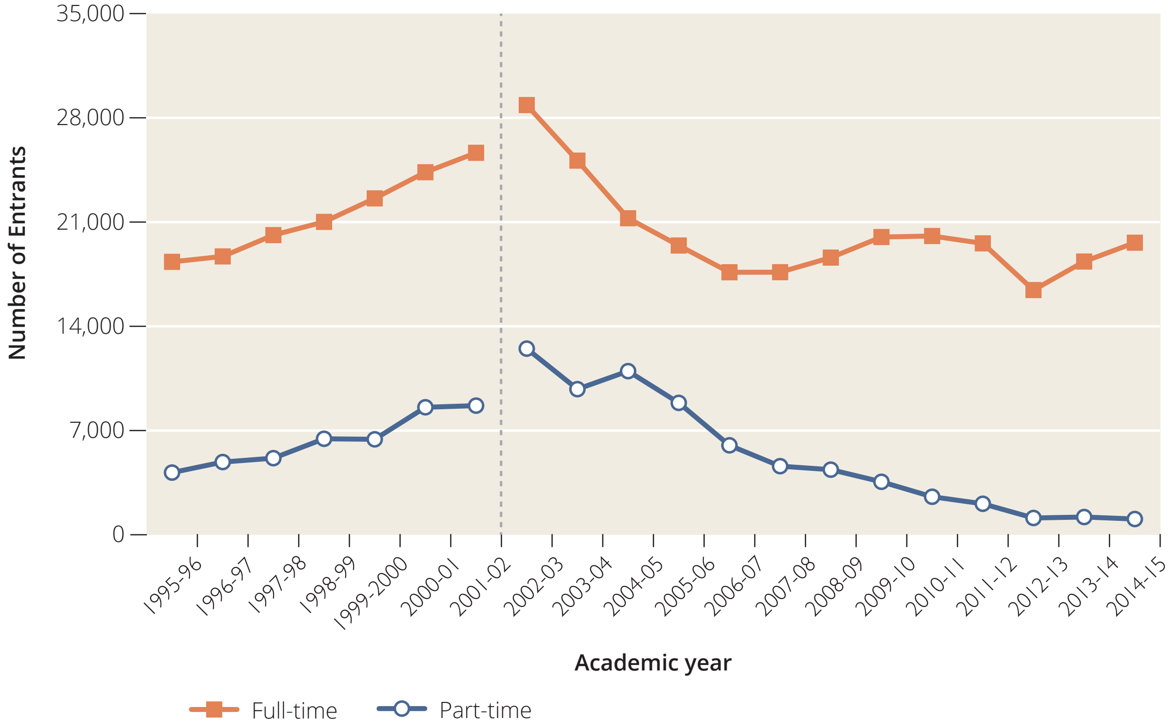
3.34 The numbers of students starting Computer Sciences degrees are, however, recovering following a dramatic drop during the mid-2000s. This followed a rapid increase in numbers during the late 1990s in response to the explosion of dot.com industries and at a time of expansion in HE provision. In 2002-03, there were almost 29,000 entrants to full-time undergraduate Computer Sciences programmes, and another 12,000 reported as studying part-time. This declined to just over 16,400 full-time entrants in 2012-13 and 1,100 part-time entrants[32], as shown in Figure 2.

3.35 The UK has, and continues to produce, Computer Sciences graduates of high quality that are sought after by employers. So while the headline data suggests that graduate employment rates for Computer Sciences is somewhat poorer than the STEM average, many English HEIs individually enjoy high graduate employment rates with their graduates going on to take up very well paid, graduate roles. Figure 3 shows the unemployment rates according to type of HEI, based on the entry qualifications of its young entrants. As a group, HEIs with high average tariff scores have lower rates of unemployment among their Computer Sciences graduates than other groups of institutions. Among UK-domiciled full-time first degree Computer Sciences graduates in 2013-14, those graduating from high average tariff institutions had an unemployment rate of 6.2 per cent. This compares with an unemployment rate of 11.7 per cent for Computer Sciences overall. The unemployment rate for medium tariff HEIs is 11.2 per cent and for HEIs with low average tariff scores is 15.3 per cent. However, the evidence also demonstrates that the student populations at these groups of HEIs are varied both in terms of their size and demography, and, as Figure 3 shows, there are variations in unemployment rate within groups of HEIs, as well as across them.

31 For an explanation of HEI groupings by UCAS tariff, see Chapter 4 – Methodology.

32 Note that prior to 2003-04 the Open University did not report subject areas of study for their students: as a result, they are effectively excluded from subject-focussed analysis of 2002-03 and earlier cohorts. To ensure comparability, figures for 2012-13 academic year also exclude students registered at the Open University.

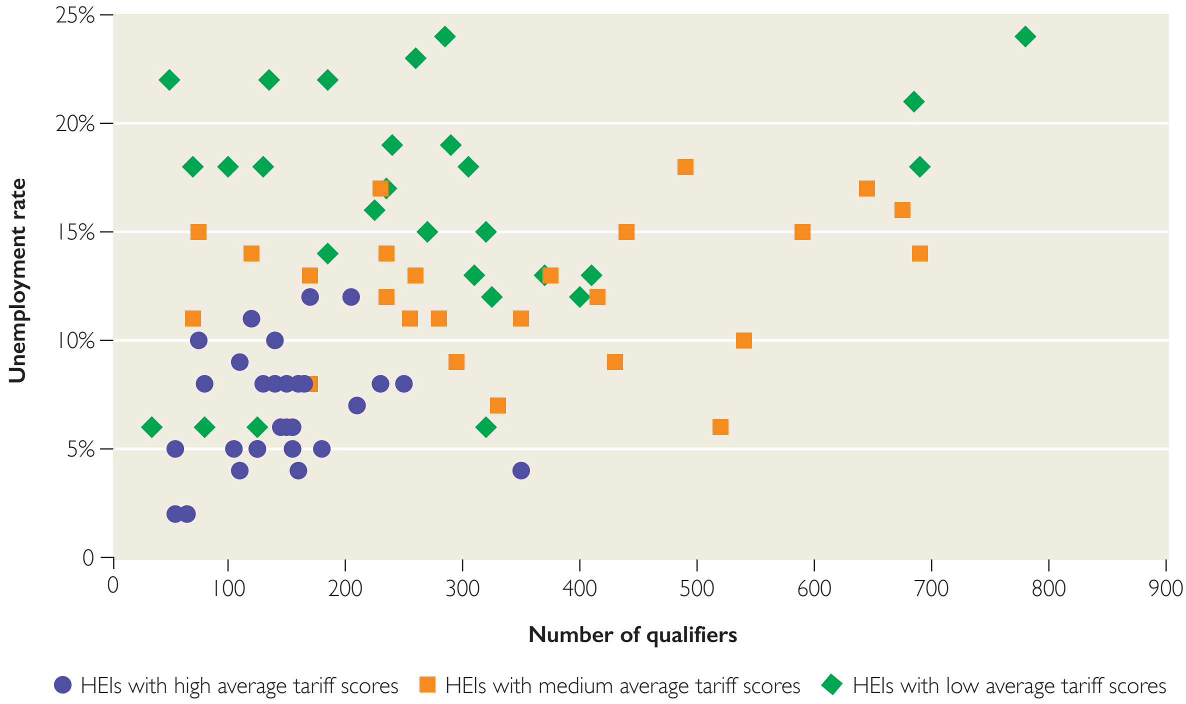
Figure 2 **Undergraduate entrants to Computer Sciences courses registered at publicly-funded English HEIs by mode of study, 1995-96 to 2014-15**



Source: HESA student records data. Figures include undergraduate entrants at publicly-funded English HEIs (excluding the Open University), across full and part-time undergraduate courses.

Note: Substantial changes were made within the HESA student record between academic years 2001-02 and 2002-03. As a result it is not possible for time series spanning this period to be entirely consistent. Figures for 2002-03 onwards are based on HEFCE analysis of the HESA standard registration population and subjects defined on the basis of JACS codes. Figures for the years prior to 2002-03 are based on HESA's count of active students as at 1 December in each academic year and based on the HESA coding of HE subject areas (as published at tables 1b and 1f of HESA's 'Students in Higher Education Institutions' publication series up to academic year 1999-2000).

Figure 3 **UK domiciled full-time first degree Computer Sciences graduates, by type of HEI and unemployment rate six months after leaving HE**



Source: HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the DLHE survey six months after leaving HE.

3.36 Although the focus of this review is the employment outcomes of Computer Sciences students graduating from first degree programmes, the postgraduate landscape is also important. A large proportion of research roles are currently filled by overseas students. Recent HESA data[33] highlights that around 45 per cent of postgraduate research Computer Sciences students are from outside the EU and that a further 15 per cent are EU-domiciled. As we have already highlighted, the supply of quality graduates is essential to the UK's research base and we identify the postgraduate issue as an area for potential further investigation in Chapter 8.

Summary

3.37 The challenges of the digital economy, and the skills and knowledge that it requires, means that both now and in the future there will be increasing demand for both intermediate level and highly specialised digital and IT skills. Computer Sciences graduates are well placed to take up the opportunities that this economy provides and to go on to enjoy successful and rewarding careers. However, the evidence also suggests that there is currently a mismatch between the skills, knowledge and attributes that some current Computer Sciences graduates possess, and the expectations of employers. The Government is already taking steps to address some of these issues at all stages of the education system. This review is therefore one part of addressing that challenge and to explore the extent of this mismatch in more detail, and to consider what additional action might need to be taken to improve the situation. It is important that reforms and recommendations across education and within industry are coordinated and meet the needs of all types of employers as well as enabling graduates to enjoy a career that will span many more technological advances.

33 HEFCE analysis of supply and demand in HE subject areas, available at: http://www.hefce.ac.uk/analysis/supplydemand/phdmph/

4 Methodology

4.1 This review is concerned with the employment outcomes of UK-domiciled full time first degree graduates from Computer Sciences undergraduate degree programmes at publicly funded HEIs in England. The review has, therefore, not explored the outcomes of graduates studying at Northern Irish, Scottish or Welsh universities, or those studying at alternative providers of higher education or Further Education Colleges (FECS). However, the review's findings will be relevant to all HE providers who offer some form of Computer Sciences provision at HE level. The review has considered accreditation systems that are currently in place and provided by the BCS and the IET.

4.2 The review has initiated, gathered and analysed a breadth of evidence arising from engagement with a broad range of representatives from the HE sector, its students, employers, and professional, statutory and regulatory bodies. This has included surveys, focus groups and roundtable discussions. The review has analysed quantitative data, in the form of graduate destinations data from HESA surveys. It also conducted a desk-based literature review of relevant reports and publications related to Computer Sciences, and wider STEM graduate employment and skills needs among employers.

4.3 The breadth of evidence gathered was important to ensure that we were able to develop and understand the true picture of graduate employment outcomes for Computer Sciences. While this picture is very much enriched by an analysis of the data available through graduate destinations surveys, it is important that a robust analysis of this landscape is supported by contextual data in the form of qualitative evidence from stakeholders. Data on the take up of work experience, for example, is currently limited. HESA student data collects information on those students who have undertaken a formal, full-year (or 'thick') sandwich year programme, but not other forms of work experience. The destinations surveys ask about both sandwich years and other forms of work experience but only to those graduates who have returned to work for the same employer that provided their work experience. This therefore excludes any other form of work experience or work placement, such as summer 'internships' or informal work experience that may have an impact on the employment outcomes of a graduate. This context is important to understanding and presenting the complexities of employment outcomes for graduates and the impact of current accreditation arrangements, which current quantitative data alone cannot provide.

4.4 The review has conducted its evidence gathering and analysis in three phases:

Phase 1 – analysis of destinations data:

4.5 Data about the destinations of graduates from Computer Sciences was interrogated to assess the extent of poor graduate employment outcomes. Data available through two surveys was considered:

- Destinations of Leavers from Higher Education (DLHE) survey – all recent UK graduates are invited to respond to this survey which is returned by students approximately six months after graduation. The survey is locally managed by HEIs using a centrally defined survey instrument. Graduates' responses are submitted to HESA's DLHE data collection. Data used in this report relates to **valid** responses received to the DLHE survey[34].

- Longitudinal Destination of Leavers from Higher Education survey (LDLHE) – a sample of graduates who provided a **valid** response to the DLHE survey are invited to respond to this survey which is collected 40 months (or 3.5 years) after graduation. This provides an indication of whether employment outcomes persist into the longer term. Data used in this report relates to valid responses received to the LDLHE survey.

4.6 The criteria for assessing the outcomes of these graduates was based on the following three employment indicators from the DLHE and LDLHE surveys:

- Graduate unemployment rate
- Proportion of graduates in 'non-graduate' roles
- Proportion of graduates earning less than £20,000[35]

4.7 Non-graduate jobs are those that fall outside of the three Standard Occupational Classification (SOC2010) major groupings of 'managers and senior officials', 'professional occupations' and 'associate professional and technical occupations'. Proportions shown are based on graduates who reported that they were in employment (only). We acknowledge that there are a range of definitions available with respect to categorising graduate and non-graduate roles and that there is no one commonly accepted definition. We have therefore selected this definition for transparency and simplicity, as it is in line with the definition of non-graduate role used in other publications and publicly available information, such as Key Information Sets (KIS), and is one that students themselves have identified in terms of understanding the nature of employment secured.

4.8 Destinations data used in the review relates to UK-domiciled full-time first degree undergraduate students registered at publicly-funded English HEIs and who fall within the HESA standard registration and the HESA qualifications obtained populations. The data measures students by 'full-person equivalents' (FPE, in broad terms a headcount measure), and classifies students by academic subject areas using the Joint Academic Coding System (JACS)[36]. Student courses often involve combinations of subjects, and (especially in the case of courses often known as Joint Honours) cannot be described by a single JACS code. The HESA student record allows for the reporting of multiple subject descriptors for each course and collects the proportion of time allocated for each subject studied on a course. In the case of balanced Joint Honours courses these proportions are generally 50 per cent for each of the two subjects; for major-minor Joint Honours courses they would typically be 67 per cent and 33 per cent; and for triple Joint Honours it would most likely be 34 per

34 A small number of students respond to the DLHE and LDLHE surveys with their explicit refusal to complete the survey.

35 The median salary for all UK domiciled leavers who obtained first degree qualifications and entered full-time paid work in the UK was £20,000 (in each of 2011-12, 2012-13 and 2013-14 graduate cohorts). The equivalent median salary among leavers from 'science subject areas' is £21,000. See tables 6 and 7 at https://www.hesa.ac.uk/index.php?option=com_content&view=article&id=1899&Itemid=634#salary

36 https://www.hesa.ac.uk/jacs3

cent, 33 per cent and 33 per cent. In order to count provision against all subjects studied by an individual student, student headcounts have been apportioned across the subject areas of study in a way that reflects the pattern of a split course. That is, in proportion to the percentage of time allocated for studying each subject. This results in counts of FPEs. Using FPEs gives a more accurate measure of HE provision than using headcounts, where the student would have to be arbitrarily assigned to one of the subjects studied in order to avoid double counting. Further information on the data with respect to the employment indicators used can be found at Annex E.

4.9 Analysis of the destinations data also considers groups of types of HEI. This is based on groupings established by HEFCE on the basis of advice from their analytical services directorate and HESA. This focuses on publicly-funded English HEIs. The groupings are as follows:

- A specialist HEI in England has been defined as an HEI that has 60 per cent or more of its provision concentrated in one or two subjects (HESA academic cost centres); examples include music or art colleges. These institutions have been identified in the first instance.
- Subsequently, non-specialist HEIs have been ranked by the average tariff score of their young (under 21) UK-domiciled undergraduate entrants in the 2014-15 academic year. The average tariff score calculation considers all such entrants holding Level 3 qualifications which are subject to the UCAS Tariff. Institutions in the top third of the ranking by average tariff score form the 'HEIs with high average tariff scores' group, and those in the bottom third comprise the 'HEIs with low average tariff scores' group.

Phase 2 – open consultation with stakeholders

4.10 The review undertook a stakeholder survey, which ran for seven weeks in July and August 2015 and received a total of 324 responses. Further details on the survey questions is available in Annex G.

Phase 3 – facilitating smaller, targeted focus groups and consultations with stakeholders to explore specific issues

4.11 The review led three focus groups to present the findings of the evidence gathered in the first two phases, according to the following topics:

- Supply and demand
- Measuring the skills gap
- Accreditation

4.12 The review also drew on evidence from a range of events, including a roundtable with Royal Society fellows held on 22 January 2016. Professor Sir Nigel Shadbolt also discussed emerging findings from the review at a Westminster Forum held on 11 February 2016 and at a meeting of UUK held on 19 February 2016.

Additional evidence gathering and governance

4.13 The review has provided input to and subsequently drawn evidence from a BIS-commissioned study into the experiences of Computer Sciences graduates in finding employment. The study, led by research group IFF, involved telephone interviews with 64 Computer Sciences graduates.

4.14 The review has also drawn on a large body of secondary evidence, including reports from the HE sector, Government, employers, PSRBs and representative organisations. A list of references is provided at the end of this report.

4.15 The review was supported in its work by an Advisory Group with membership drawn from employers, the HE sector and professional bodies. The Group met four times between April 2015 and January 2016, and provided a valuable sounding board for both the emerging findings and recommendations from the review. The input to the work through the discussions at the Advisory Group meetings has been invaluable and has contributed to an enriched discussion for which we are grateful. Terms of Reference are set out at Annex C, and the Advisory Group membership at Annex B.

5 What the data tells us – quantitative analysis

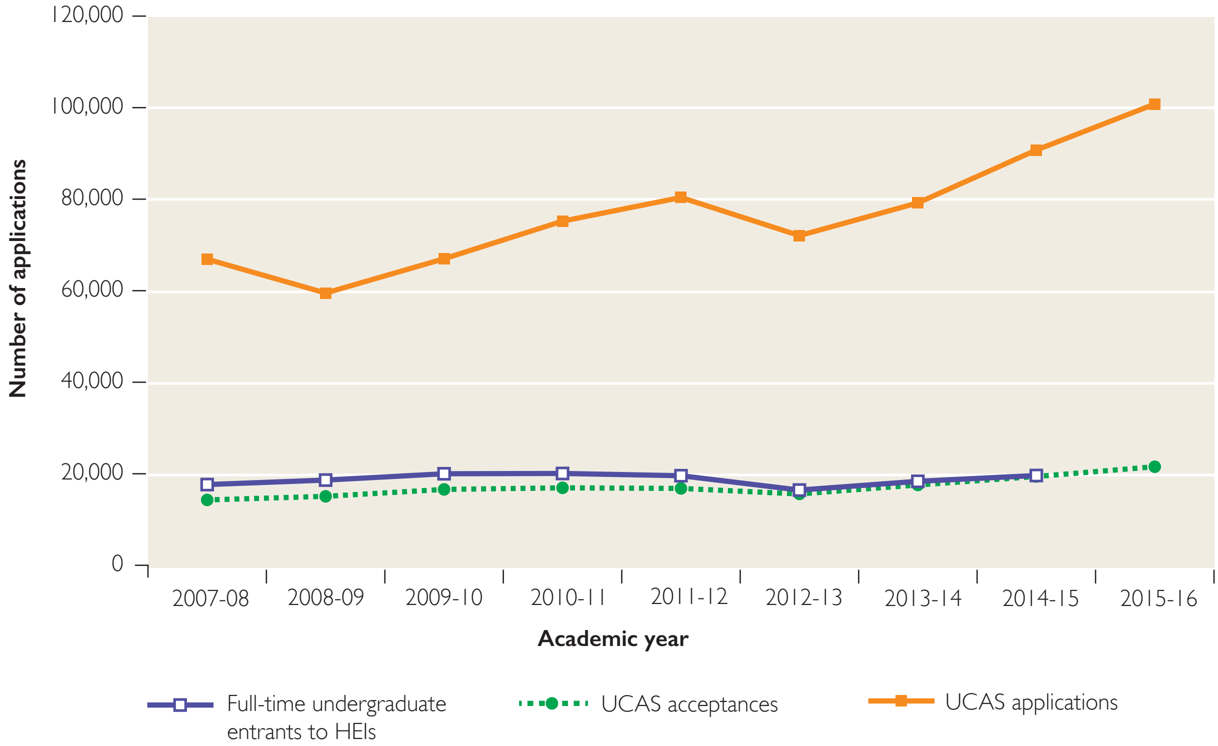
Supply

Scale of provision

5.1 Computer Sciences, and its sub disciplines, is offered at undergraduate level at the large majority of English HEIs, with 95 of 130 English HEIs reporting students studying Computer Sciences in 2014-15. Most other STEM subjects are concentrated in a smaller number of institutions. For example, 56 HEIs in England reported students studying Physics, 50 offer Civil Engineering and 69 offer Electrical and Electronic Engineering. Mathematical Sciences is reported at 75 HEIs.

5.2 Prospective students can apply to almost 2,000[37] different undergraduate courses related to Computer Sciences with just over 10 per cent, the largest number, of those courses with the title 'Computer Science'. Applications to study Computer Sciences at undergraduate level grew for the third consecutive year in 2015-16 with 100,775 applications to English HEIs made via UCAS[38]. And applications into 2016-17, as at UCAS'

Figure 4 **Applications and acceptances for full-time undergraduate entrants to publicly-funded English HEIs, 2007-08 to 2014-15**



Source: HEFCE analysis of the HESA standard registration population, full-time undergraduate entrants to publicly-funded English HEIs, 2007-08 to 2014-15. UCAS end of cycle data resources: applications and acceptances for types of higher education course – 2015 (subject group and country of provider).

37 The Unistats website lists 1,945 course titles in the computer science subject area for 2015, including full-time and part-time courses at undergraduate level.

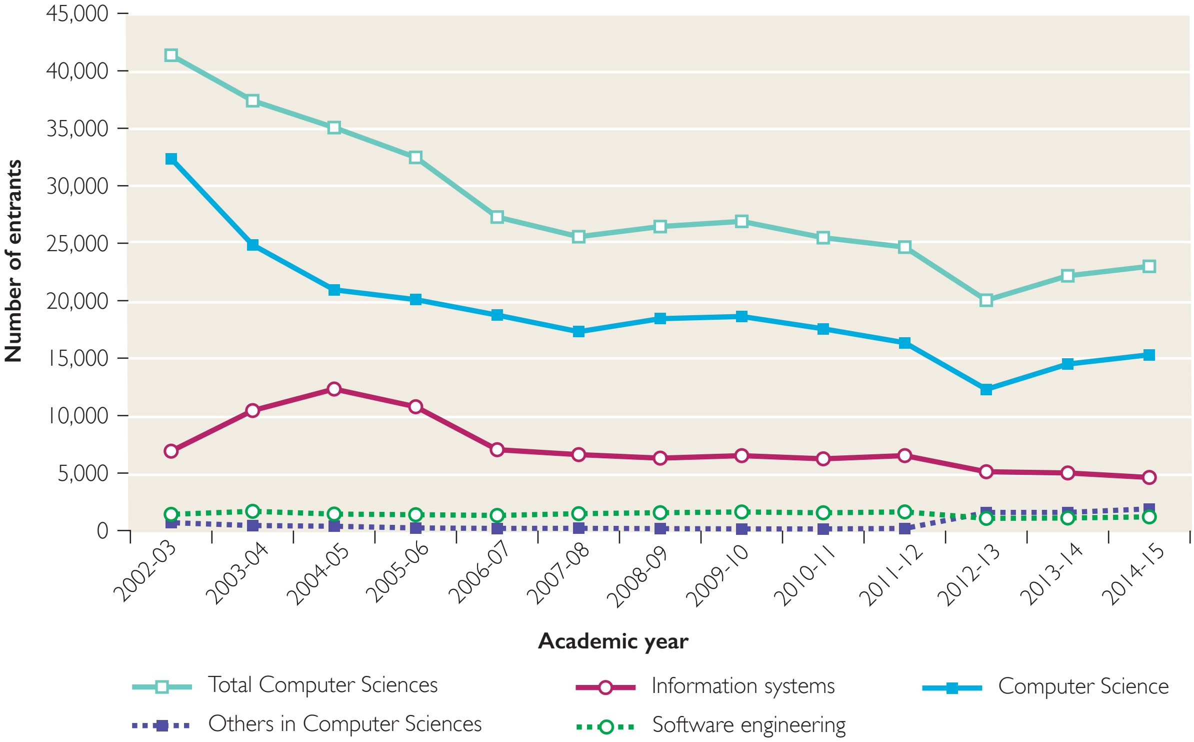
38 Applicants can make up to five course applications – application figures relate to an unknown number of individual applicants.

January deadline, indicate a continuation of that growth trajectory. Figure 4 shows the applications, acceptances and entrants to Computer Sciences from 2007-08 to 2014-15, and applications and acceptances in 2015-16. Numbers are recovering following a dip in 2012-13. In 2014-15, there were 19,615 students who began full-time undergraduate Computer Sciences programmes at publicly-funded English HEIs from a total of 90,735 applications.

5.3 In 2002-03, the number of undergraduate students reported to be studying Computer Sciences[39] peaked at 41,355 (FPE)[40]. This then fell to 20,035 in 2012-13, before recovering to 22,985 in 2014-15. This is in line with the sector as a whole, which is continuing the recovery of undergraduate entrant numbers following the introduction of increased fees in 2012-13.

5.4 There are variations in student numbers within the Computer Sciences grouping of subjects. The numbers of students taking courses in Software Engineering, Information Systems, and Others in Computer Science[41] have been more consistent than those seen in Computer Sciences as Figure 5 shows. The impact of the 2012-13 HE fees and funding regime changes seems to have been particularly pronounced for Computer Sciences, compared with other subjects, with numbers around 10 per cent lower in 2014-15 than in 2010-11 – although as Figure 5 shows, the numbers are recovering. Analysis of a wider set of HE subject areas indicates that this is in line with broader recovery in entrants to undergraduate higher education in England.

Figure 5 **Undergraduate entrants to Computer Sciences at publicly-funded English HEIs, 2002-03 to 2014-15 by sub discipline**



Source: HEFCE analysis of the HESA standard registration population, undergraduate entrants to publicly-funded English HEIs, 2002-03 to 2014-15.

39 Computer Sciences includes programmes returned to HESA as Computer Sciences, Artificial Intelligence, Software Engineering and Information Systems, and Others in Computer Sciences. Further information is available at Annex F.

40 2002-03 figures do not include students registered at the Open University where subject and level of study were not identified in their administrative data. In the period from 2003-04 to 2008-09 they reported 2,500 to 3,500 students per year as studying undergraduate Computer Sciences courses.

41 Since 2012-13, HESA has collected information on students studying the following programmes which fall within the Computer Sciences group: Health informatics; Games, and Computer generated visual & audio effects. For the purposes of data analysis, these students are included within Others in Computer Sciences, along with artificial intelligence.

Who is studying Computer Sciences?

5.5 Data relating to employment outcomes of Computer Sciences graduates is complex and is therefore presented in a number of ways in the following section of the report. This is intentional and attempts to convey the complexity of both the employment and HE landscape. Selecting one statistic to represent the employment outcomes of all Computer Sciences graduates is not possible and provides a misleading view of the subject.

5.6 Of the 22,985 undergraduate entrants to Computer Sciences in 2014-15, 15,965 were UK-domiciled entrants to full-time first degree programmes. Accounting for 69 per cent of the undergraduate entrant cohort for this subject area[42], this population equates to the one for whom the DLHE survey collects the most meaningful data. Employment outcomes of part-time students are difficult to interpret because we know that high proportions are in employment at the same time as studying HE part-time. So in terms of the destinations reported six months after leaving HE through the DLHE survey, we do not know whether this destination is simply the one that they experienced throughout their studies (i.e. employment), or an enhanced version of that (i.e. pay rise, promotion or career change). Similarly, HEIs are expected to meet, or exceed, a target response rate for DLHE of 80 per cent for UK-domiciled HE leavers who previously studied full-time – which goes some way to ensure that statistics derived from DLHE data genuinely reflect the outcomes of students leaving HE.

5.7 Destinations data referenced within this report therefore relates to UK-domiciled full-time first degree graduates between 2011-12 and 2013-14, unless otherwise stated. Table 1 shows the numbers of Computer Sciences students who graduated between 2007-08 and 2013-14 who were unemployed six months after graduation. Overall, unemployment rates among Computer Sciences graduates have continued to fall since 2011-12, when 14.9 per cent of graduates were unemployed six months following graduation. 11.7 per cent of graduates from the 2013-14 cohort were unemployed six months after graduation. And this is consistent for all types of student, regardless of ethnicity, age or whether they came from an area with low participation in HE.

Table 1 **Employment outcomes of UK-domiciled full-time first degree graduates from STEM and Computer Sciences six months after leaving HE: graduates from publicly-funded English HEIs, 2007-08 to 2013-14**

	2007-08 graduates	2008-09 graduates	2009-10 graduates	2010-11 graduates	2011-12 graduates	2012-13 graduates	2013-14 graduates
STEM: Unemployment rate	10.6%	12.5%	11.4%	10.9%	10.7%	9.5%	8.4%
STEM: Non-graduate job	26.3%	31.0%	29.6%	27.8%	25.9%	25.5%	24.0%
STEM: Low salaries	39.6%	44.1%	45.6%	42.2%	39.1%	36.9%	35.0%
Computer Sciences: Unemployment rate	15.0%	18.1%	15.1%	15.0%	14.9%	13.2%	11.7%
Computer Sciences: Non-graduate job	24.3%	28.8%	25.5%	24.2%	20.8%	22.3%	20.0%
Computer Sciences: Low salaries	41.5%	44.8%	44.4%	35.7%	34.5%	34.5%	32.9%

Source: HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2007-08 to 2013-14. Graduates who subsequently provided a valid response to the DLHE survey six months after leaving HE.

42 The proportion covered by this definition has increased from around 50 per cent in 2008-09, largely on account of wider declines in the take up of part-time study and smaller numbers of non-EU students in more recent cohorts.

5.8 Table 1 and Figure 6 show that among graduates in employment only (rather than in a combination of work and further study), a lower proportion of Computer Sciences graduates were employed in non-graduate roles than we see among STEM graduates generally. This applies across the time series considered: in the most recent 2013-14 cohort, 20 per cent of Computer Sciences graduates were employed in non-graduate roles compared with 24 per cent of all STEM graduates. Similarly, Computer Sciences graduates in full-time paid UK employment six months after leaving HE were less likely to have been earning low salaries than equivalent graduates across all STEM subjects. In 2013-14, around a third of such Computer Sciences graduates reported earning less than £20,000.

5.9 Among the 7,485 UK-domiciled full-time first degree graduates from publicly-funded English HEIs in 2013-14 who provided a valid response to the DLHE, the number who reported that they were in paid full-time UK employment (only) and in a graduate-level role (4,175) was almost five times higher than the number of graduates who reported that they were unemployed (880). And the number who reported that they were in paid full-time UK employment and reported earning £20,000 or more (2,345) was almost three times higher than the number who reported they were unemployed.

Figure 6 **Employment outcomes of UK-domiciled full-time first degree graduates from STEM and Computer Sciences six months after leaving HE: qualifiers from publicly-funded English HEIs, 2011-12 to 2013-14**

Source: HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2007-08 to 2013-14. Graduates who subsequently provided a valid response to the DLHE survey six months after leaving HE.

5.10 And unemployment rates fall further 40 months (or 3.5 years) following graduation. According to LDLHE survey data, 5.0 per cent of Computer Sciences students who graduated in 2010-11 were assumed to be unemployed by the second, 40 month, census point. This is slightly higher than the figures for all graduates from STEM disciplines and for leavers across all subjects, where the proportions assumed to be unemployed are 3.2 per cent and 2.9 per cent respectively. However, both the proportion of Computer Sciences graduates in non-graduate roles and those earning low salaries is significantly reduced by 40 months and is lower than the outcomes for all STEM and, in particular, for all HE subjects. Table 2 provides a summary of outcomes for Computer Sciences graduates compared to STEM graduates at 40 months. This is reinforced by the Office for National Statistics (ONS) Labour Force Survey 2013, which found that annual earnings for graduates reach a higher peak later in their career[43].

Table 2 **Employment outcomes of UK-domiciled full-time first degree graduates from STEM and Computer Sciences 40 months after leaving HE: graduates from publicly-funded English HEIs, 2008-09 and 2010-11**

	2008-09 graduates			2010-11 graduates		
	Computer Sciences	STEM	All HE subjects	Computer Sciences	STEM	All HE subjects
Unemployment rate	5.7%	3.6%	3.5%	5.0%	3.2%	2.9%
Non-graduate job	17.4%	15.0%	21.4%	13.4%	14.5%	23.2%
Low salaries	23.5%	18.5%	27.5%	16.8%	17.3%	26.0%

Source: HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2008-09 and 2010-11. Graduates who subsequently provided a valid response to the LDLHE survey 40 months after leaving HE.

5.11 Table 3 provides a profile of graduates from Computer Sciences degree courses by type of HEI. The groupings relate to the average UCAS tariff scores achieved by young (under 21) UK-domiciled undergraduate entrants to an HEI holding Level 3 qualifications which are subject to the UCAS Tariff (see Chapter 4 – Methodology – for further information on the institutional groupings). The same profile is given for all STEM graduates in the same time period. Further detail on the employment outcomes of Computer Sciences graduates according to these different profiles, including student background and type of degree programme studied, are explored in more detail in the analysis later in this chapter.

5.12 In broad terms, Table 3 highlights differences in the profile of Computer Sciences graduates compared with all STEM graduates in terms of a number of important student and course characteristics. For example, there are far fewer women graduating from Computer Sciences than from STEM more broadly. There are also far fewer students graduating from integrated Masters courses, with a significant proportion of these graduating from HEIs with the highest average tariff scores. Conversely, Computer Sciences has higher proportions of students who were mature, from a BME ethnic background or who studied on a sandwich course, when compared to STEM overall. While low tariff HEIs have a larger proportion of under-represented groups, including BME, mature and

43 www.ons.gov.uk/ons/dcp171776_337841.pdf

students from low participation neighbourhoods (LPNs), they also offer the lowest number of courses that include a formal sandwich year.

Table 3 **Profile of graduates from Computer Sciences and all STEM by student characteristic and type of HE provider (based on tariff scores) – 2011-12 to 2013-14**

HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2007-08 to 2013-14. Qualifiers who subsequently provided a valid response to the DLHE survey six months after leaving HE.

	Computer Sciences					All STEM				
	Specialist HEIs	HEIs with high average tariff scores	HEIs with medium average tariff scores	HEIs with low average tariff scores	Overall	Specialist HEIs	HEIs with high average tariff scores	HEIs with medium average tariff scores	HEIs with low average tariff scores	Overall
% female	68%	14%	17%	15%	16%	40%	37%	33%	31%	35%
% male	32%	86%	83%	85%	84%	61%	63%	67%	69%	65%
% mature	9%	9%	20%	29%	21%	21%	5%	18%	28%	14%
% young	91%	91%	80%	71%	79%	79%	95%	82%	72%	87%
% white	64%	74%	67%	67%	68%	70%	79%	68%	70%	74%
% BME	36%	26%	34%	33%	32%	30%	21%	32%	31%	27%
% LPN	35%	9%	13%	14%	13%	7%	6%	12%	12%	9%
% not LPN	65%	91%	87%	86%	87%	93%	94%	89%	88%	91%
% disabled	21%	11%	12%	11%	11%	15%	10%	11%	12%	11%
% not disabled	79%	89%	88%	89%	89%	85%	90%	89%	88%	89%
% sandwich course	0%	21%	25%	13%	20%	12%	9%	16%	8%	11%
% not a sandwich course	100%	79%	75%	87%	80%	88%	91%	84%	92%	89%
% integrated Masters	0%	17%	2%	1%	4%	2%	39%	10%	6%	23%
% other first degree courses	100%	83%	98%	99%	96%	99%	62%	90%	94%	77%

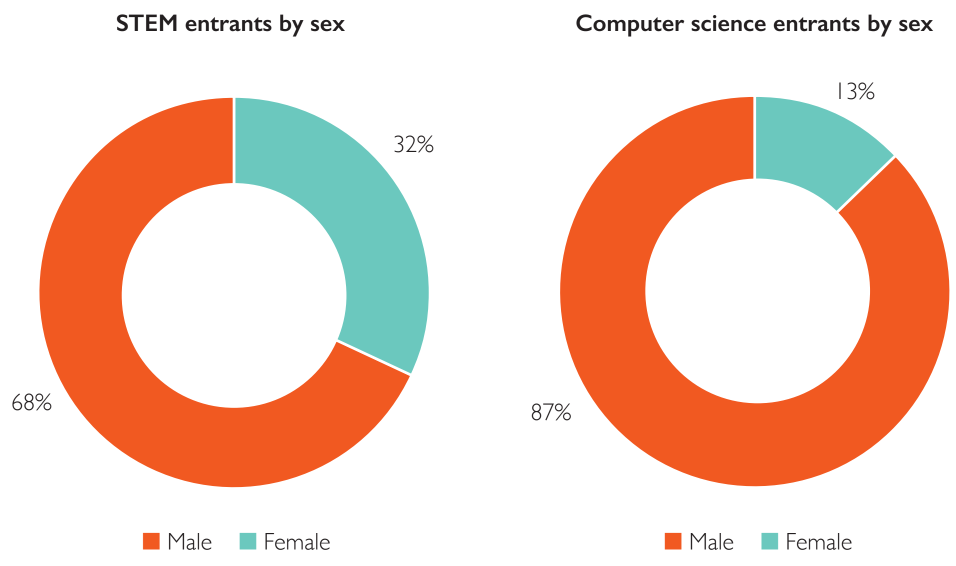
5.13 The analysis below presents graduate destinations data that is contextualised by student data describing the profile of students who start Computer Sciences courses (entrant cohorts). The student data relates to UK-domiciled full-time first degree entrants up to academic year 2014-15. This population definition aligns with the destinations data, which considers an equivalent population of UK-domiciled full-time first degree graduates. The most recent cohorts of graduates between 2011-12 and 2013-14 are described, unless otherwise stated.

5.14 Comparisons of the employment outcomes for each group are made with the equivalent group at the 'all STEM' level. Finally a comparison is then made using previous research undertaken by HEFCE to consider the employment outcomes of all HE graduates according to different equality groups, *Differences in employment outcomes: equality and* *diversity characteristics*[44]. The HEFCE research includes statistical modelling which helps to examine the early career employment outcomes of UK-domiciled students who graduated from a full-time first degree course in the academic year 2008-09. It identifies differences in employment outcomes for different equality groups when other background characteristics have been controlled for (such as the institution the student studied at and the A-Level results they obtained) among those graduating from publicly-funded English HEIs. While the cohort examined in the wider HEFCE research is not the most recent, it enables a comprehensive analysis of whether differences seen in a graduate's early career persist into the medium term. Comparisons with the outcomes of this previous research are therefore intended to provide an indication of the likelihood of an identified difference persisting into the medium term, and to clarify whether other characteristics of the student or course might be contributing to any differences observed here. This can help to identify whether there are any issues that might be unique to graduates from Computer Sciences or if patterns in outcomes are evident elsewhere.

Sex

5.15 In 2014-15, there were 2,025 female entrants to full-time Computer Sciences degree programmes at publicly-funded English HEIs, representing just 13 per cent of the total number of first degree entrants. This is a proportion that has remained consistent with 2013-14 but has been in steady decline, from almost 20 per cent in the early 2000s. Figure 7 shows how sex is represented in Computer Sciences as compared to other STEM disciplines. It is low compared to 32 per cent of female first degree entrants across all STEM programmes (a proportion that has remained broadly stable over the last decade). The review acknowledges that much more needs to be done to increase the numbers of women who study Computer Sciences. This is an urgent issue outside the scope of this review.

Figure 7 **Proportion of Computer Sciences entrants and all STEM entrants by sex, 2014-15**



Source: HEFCE analysis of the HESA standard registration population, UK-domiciled full-time first degree entrants at publicly-funded English HEIs in 2014-15.

44 www.hefce.ac.uk/pubs/year/2015/201523/

5.16 Destinations data shows that the unemployment rate among female Computer Sciences graduates was slightly lower than that of equivalent male graduates when the three qualifying cohorts 2011-12 to 2013-14 are combined. While male graduates had an unemployment rate of 13.2 per cent six months after leaving HE, among female graduates the rate was 13.0 per cent. 70 per cent of female Computer Sciences graduates reported that they were in employment only, compared to 75 per cent of male graduates. However, when we combine this figure with those who went on to further study or into a combination of employment and further study, the results show very similar outcomes for male and female graduates: 83 per cent of female graduates were in employment or further study compared to 84 per cent of male graduates. Of those in employment only, 30 per cent of female graduates were in a non-graduate role, compared with 20 per cent of male graduates. And among those in full-time paid UK employment, 42 per cent of female graduates were earning less than £20,000 compared to 33 per cent of male graduates.

5.17 The analysis shows that the proportion of female Computer Sciences graduates in non-graduate roles is around 10 percentage points higher than the proportion of equivalent male graduates. This is consistent with the overall STEM picture, where female graduates are seen to have the higher proportion (by around 7 percentage points) in non-graduate jobs six months after leaving HE.

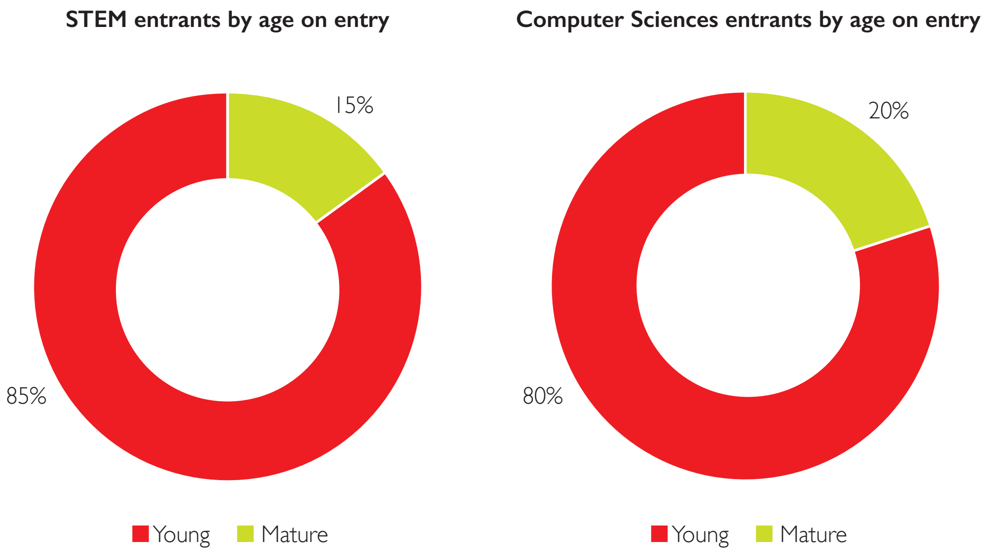
5.18 Across all UK-domiciled full-time first degree graduates from English HEIs, the proportions of male and female graduates who had gained employment in a graduate role six months after leaving HE were broadly the same. However, some of this similarity in outcomes was explained by other student and course characteristics. Once these were accounted for, male graduates were around three per cent more likely to have gained a graduate job than their female counterpart. While the direction of this finding is consistent with the one we observe for Computer Sciences graduates, the scale of the difference is more pronounced for graduates from Computer Sciences.

5.19 If we then consider other student characteristics in conjunction with gender, we find that some differences remain. For example, the proportion of white female Computer Sciences graduates in a non-graduate role was ten percentage points higher than the proportion among white male Computer Sciences graduates. And the proportion of BME female Computer Sciences graduates was seven percentage points higher than among BME males. We find similar patterns when male and female Computer Sciences graduates are analysed according to whether they grew up in an area where a low number of young people enter HE – or Low Participation Neighbourhoods. Here we see that differences between males and females from LPN backgrounds are smaller than differences between males and females from non-LPN backgrounds.

Age

5.20 The number of mature first degree entrants to Computer Sciences has remained broadly stable for the last decade following an initial drop in the aftermath of the expansion and subsequent contraction of Computer Sciences provision. In 2002-03, mature entrants to full-time first degrees in Computer Sciences numbered 5,780 and

Figure 8 **Proportion of Computer Sciences entrants and all STEM entrants by age on entry, 2014-15**



Source: HEFCE analysis of the HESA standard registration population, UK-domiciled full-time first degree entrants at publicly-funded English HEIs in 2014-15.

accounted for 28 per cent of the total (meaning that 14,885 of the total 20,665 entrants were young). Figure 8 captures the current picture of Computer Sciences entrants by age. While the Government has lifted the cap on student numbers allowing more people to enter HE, between 2015 and 2020 the 18 year old population is expected to fall by around 75,000 – so any increases in young entrants to HE will be in a challenging demographic environment[45].

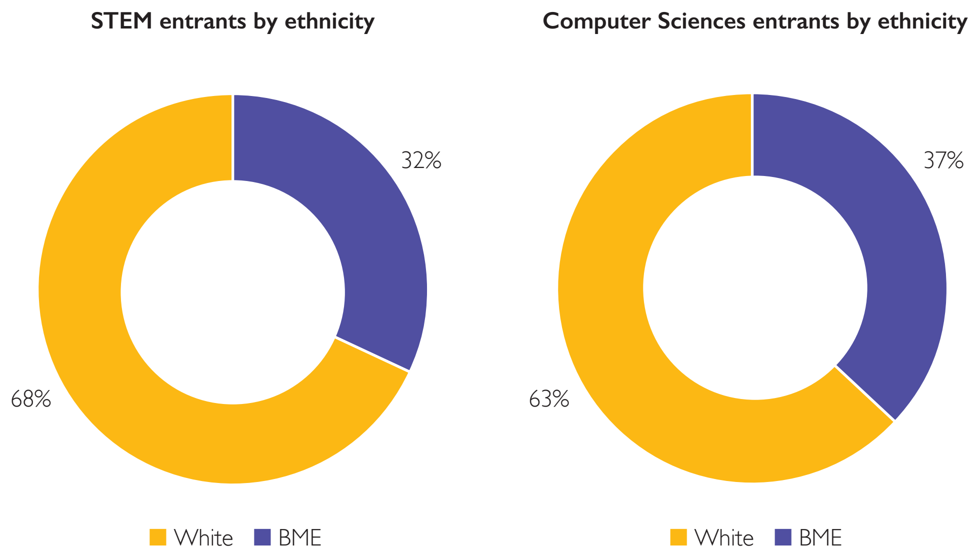
5.21 Data from the 2011-12 to 2013-14 DLHE surveys of graduates show differences in employment outcomes for mature and young entrants. While young graduates had an unemployment rate of 12.1 per cent six months after leaving HE, among mature graduates the rate was 17.3 per cent. 66 per cent of mature graduates who returned a valid response to the survey between 2011-12 and 2013-14 were in employment only, compared to 76 per cent of young entrants during the same time period. These figures are more closely aligned when employment is combined with further study: 85 per cent of young graduates and 79 per cent of mature graduates were either employed, in further study or in a combination of both six months after graduation. Of those in employment only, 21 per cent of young and 23 per cent of mature graduates were in a non-graduate role. And among those in full-time paid UK employment, 34 per cent of young and 37 per cent of mature graduates were earning less than £20,000.

Ethnicity

5.22 BME entrants onto Computer Sciences first degree programmes totalled 5,725 in 2014-15, accounting for 37 per cent of entrants with known ethnicity. Of these, 84 per cent were reported at institutions with low or medium average tariff scores: at 15 per cent, the proportion of BME Computer Science entrants reported at high tariff institutions was four

[45] ONS statistics in HE in England, HEFCE, 2015

Figure 9 **Proportion of Computer Sciences entrants and all STEM entrants by ethnicity, 2014-15**



Source: HEFCE analysis of the HESA standard registration population, UK-domiciled full-time first degree entrants at publicly-funded English HEIs in 2014-15. Entrants with unknown ethnicity have been excluded from the proportions shown here.

percentage points lower than that among white entrants. Figure 9 shows the number of Computer Sciences entrants by ethnicity as compared to all STEM entrants by ethnicity.

5.23 Data from the 2011-12 to 2013-14 DLHE surveys of graduates show that BME graduates had an unemployment rate of 17.3 per cent six months after leaving HE, compared with a rate of 11.2 per cent among white graduates. 79 per cent of BME graduates were in employment and/or further study, compared to 86 per cent of white graduates.

5.24 Across all STEM subjects, the proportion of BME graduates in employment or further study six months after leaving HE was 83 per cent, while among white graduates the proportion was 88 per cent. Of those STEM graduates in employment only, 24 per cent of white and 27 per cent of BME graduates were in non-graduate roles. And 35 per cent of white and 43 per cent of BME graduates were earning low salaries.

5.25 There are marked differences between the numbers of white and BME graduates who are in graduate roles six months after graduation. Of those in employment only, 31 per cent of BME graduates were in a non-graduate role, compared with 17 per cent of white graduates. However, among those in full-time paid UK employment, the proportion of both BME and white graduates earning less than £20,000 was 34 per cent.

5.26 Information provided in Figure 13 later in the report shows that the absence of a difference in the proportions of white and BME Computer Sciences graduates earning low salaries is at odds with the picture observed across all STEM graduates, where white graduates were 8 percentage points less likely to be earning low salaries than their BME counterparts. Similarly, the presence of a difference between white and BME Computer Sciences graduates in terms of the proportion in non-graduate roles also highlights a difference to the overall STEM picture. While the proportion of BME STEM graduates in non-graduate roles was 27 per cent, it was only three percentage points higher than the proportion among white STEM graduates (compared with the 14 percentage point difference we have observed for Computer Sciences graduates).

5.27 HEFCE research into different outcomes according to equality groups finds that BME graduates across all HE subjects were less likely to be working in graduate jobs than their white counterparts, with differences in both observed employment outcomes and in those modelled to take account of the students' other background and course characteristics. The results described here for Computer Sciences graduates are therefore consistent (if not slightly more extreme) with those sector level results.

5.28 When Computer Sciences graduates are considered further, by ethnicity in conjunction with other student characteristics, we find:

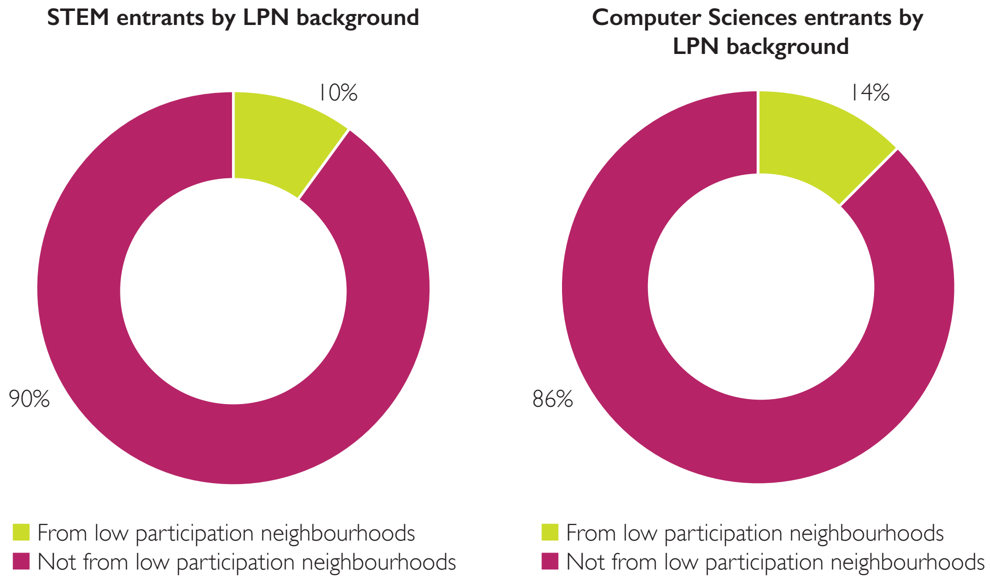
- **Ethnicity and student's age on HE entry**: the proportion of white graduates employed in non-graduate roles is consistent regardless of age. However this is not the case for BME graduates, where young students were seven percentage points less likely to be in a non-graduate role than a mature BME graduate. The same patterns are seen across the other employment indicators - young and mature white graduates have similar unemployment rates and proportions earning low salaries, but BME graduates show differences by age.

  Ethnicity and LPN background: there are only marginal differences in the numbers unemployed when a graduate's background is considered alongside their ethnicity. 13 per cent of white LPN students compared to 11 per cent of white non LPN students. And for BME graduates these figures are 18 per cent for LPN graduates and 17 per cent for non LPN graduates. Similarly, differences between LPN and non-LPN graduates are consistent in terms of the proportions of graduates earning low salaries (42 per cent and 33 per cent respectively for white graduates and 41 per cent and 34 per cent for BME graduates). But a contrast is found in the proportions of LPN and non-LPN graduates employed in non-graduate jobs. A higher proportion of white graduates from LPN backgrounds were in non-graduate roles (compared with non-LPN graduates) but the opposite is found for BME graduates where those from non LPN backgrounds were more likely to be working in non graduate roles.

Young entrants from areas with low HE participation/Low Participation Neighbourhoods (LPN)

5.29 Growth in the proportion of Computer Sciences entrants from LPNs over the last decade has been around double that for all STEM entrants. Figure 10 illustrates the proportion of Computer Sciences entrants from an LPN background as compared to those not from an LPN. It also shows how that proportion compares to all STEM entrants. Around 14 per cent of young full-time first degree entrants to Computer Sciences programmes in 2014-15 were from LPN backgrounds, an increase from around 10 per cent in the early 2000s. This compares with a proportion of 10 per cent among all STEM entrants in 2014-15, having increased from eight per cent in the same period.

Figure 10 **Proportion of Computer Sciences entrants and all STEM entrants by LPN background, 2014-15**



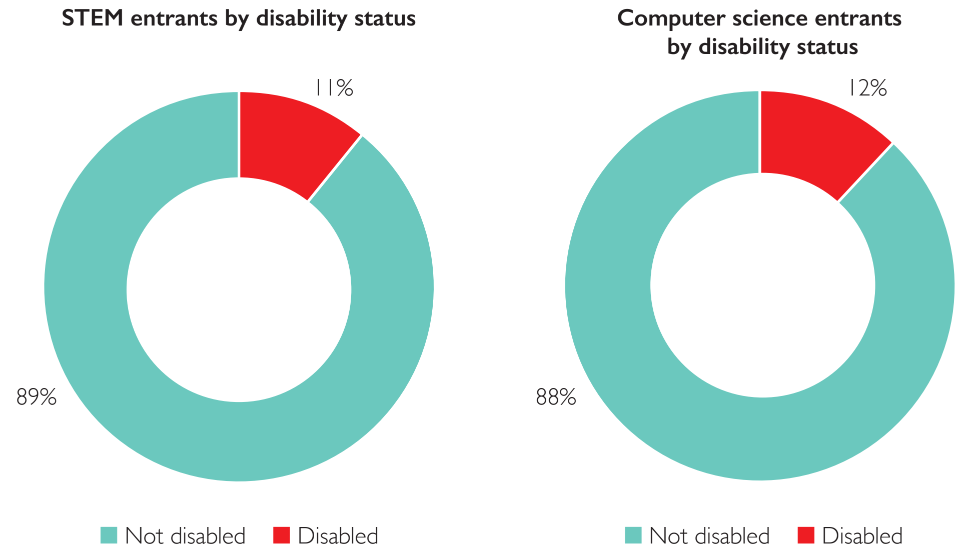
Source: HEFCE analysis of the HESA standard registration population, young UK-domiciled full-time first degree entrants at publicly-funded English HEIs in 2014-15. Entrants with unknown postcode have been excluded from the proportions shown here.

5.30 Destinations data show that the unemployment rate of young graduates from LPNs was 1.3 percentage points higher than that of equivalent graduates not from an LPN when the three qualifying cohorts 2011-12 to 2013-14 are combined. While LPN graduates had an unemployment rate of 13.3 per cent six months after leaving HE, among non-LPN graduates the rate was 11.9 per cent. 77 per cent of LPN Computer Sciences graduates reported that they were in employment only, compared to 76 per cent of non-LPN graduates. However, when we combine this figure with those who went on to further study or into a combination of employment and further study, the results show very similar outcomes for LPN and non-LPN graduates: 84 per cent of LPN graduates were in employment or further study compared to 85 per cent of non-LPN graduates. Of those in employment only, 21 per cent of both LPN and non-LPN qualifiers were in a non-graduate role. And among those in full-time paid UK employment, 41 per cent of LPN graduates were earning less than £20,000 compared to 33 per cent of non-LPN graduates.

Disability

5.31 Disabled entrants onto Computer Sciences first degree programmes totalled 1,945 in 2014-15, accounting for 12 per cent of all UK-domiciled full-time first degree entrants as set out in Figure 11. This proportion is in line with that observed across all STEM subjects, where 11 per cent of 2014-15 entrants had a disability.

Figure 11 **Proportion of Computer Sciences entrants and all STEM entrants by disability, 2014-15**



Source: HEFCE analysis of the HESA standard registration population, UK-domiciled full-time first degree entrants at publicly-funded English HEIs in 2014-15.

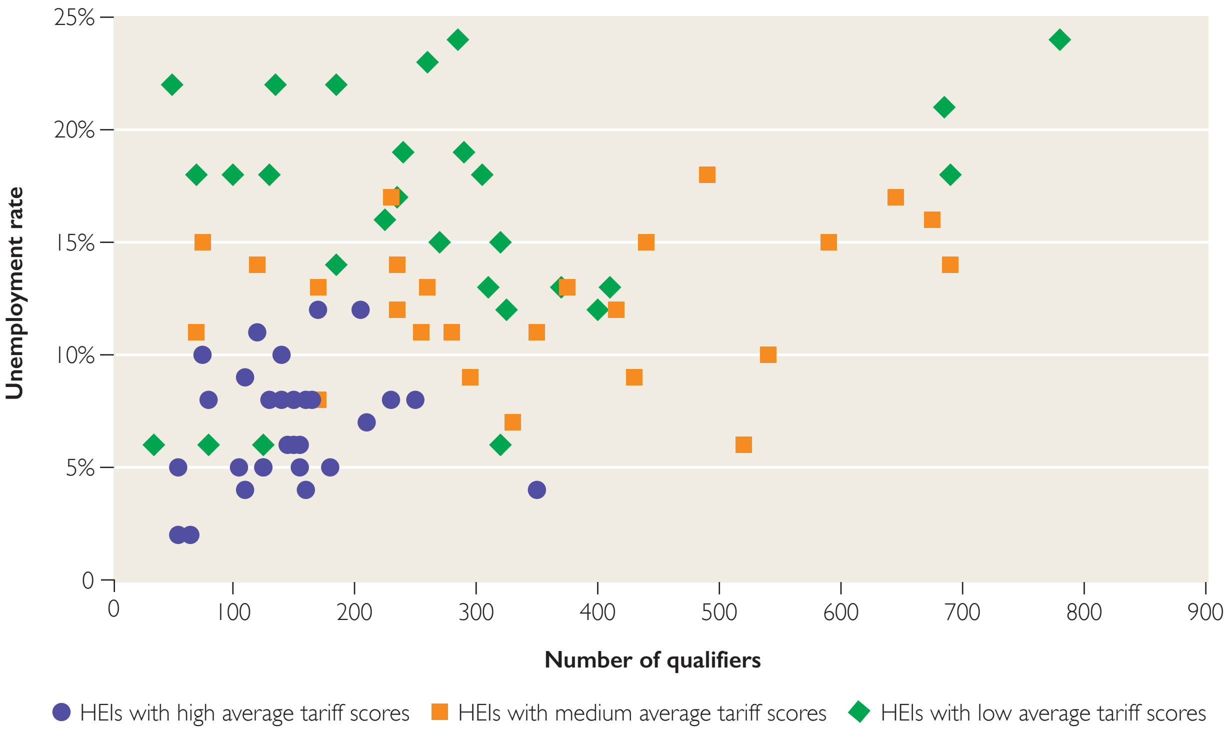
5.32 Data from the 2011-12 to 2013-14 DLHE surveys of graduates shows differences in employment outcomes for disabled students. While non-disabled graduates had an unemployment rate of 12.8 per cent six months after leaving HE, among disabled graduates the rate was 16.6 per cent. 75 per cent of non-disabled graduates who returned a valid response to the survey between 2011-12 and 2013-14 were in employment only, compared to 69 per cent of disabled entrants during the same time period. When employment is combined with further study, 84 per cent of non-disabled graduates and 80 per cent of disabled graduates were either employed, in further study or in a combination of both six months after graduation. Of those in employment only, 17 per cent of disabled and 22 per cent of non-disabled graduates were in a non-graduate role. And among those in full-time paid UK employment, 33 per cent of disabled and 34 per cent of non-disabled graduates were earning less than £20,000.

5.33 HEFCE research to consider employment outcomes across all HE graduates has found that disabled students had an employment rate six months after leaving HE that was around three percentage points lower than graduates who were not disabled. That work found that this difference in employment outcomes of disabled students was not explained by other characteristics of the student or their courses (including subject area of study). This corresponds with the outcomes of disabled graduates from Computer Sciences.

Employment outcomes – where and what you studied

5.34 As Table 3 and the analysis by student group above demonstrates, Computer Sciences attracts a broad range of students who choose to study at a broad range of HEIs. These HEIs display substantial differences in the proportion of their graduates who appear to be unemployed. Figure 12 shows, by type of HEI, the number of graduates from Computer Sciences over a three-year period from 2011-12 to 2013-14 who were unemployed six months after graduation. The groupings relate to the average UCAS tariff scores achieved by young (under 21) UK-domiciled undergraduate entrants to an HE provider holding Level 3 qualifications which are subject to the UCAS Tariff (see Chapter 4 – Methodology – for further information on the institutional groupings). While each type of HEI shows a range of unemployment rates, some HEIs with the lowest average tariff scores have both the highest number of graduates and the highest number of graduates who were recorded as unemployed. Figure 12 also shows how unemployment rates are spread across a wide number of HEIs, with the highest unemployment rates concentrated in a small number of HEIs. These tend to be those with the lowest average tariff scores.

Figure 12 **UK domiciled full-time first degree Computer Sciences graduates, by HEI type and unemployment rate six months after leaving HE**



Source: HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the DLHE survey six months after leaving HE.

5.35 Employment outcomes for Computer Sciences graduates vary, not just according to the graduate's background or where they choose to study, but also by the type of degree course they opt for. Sandwich year programmes offer students the opportunity to work in industry, usually for one year during their studies. This is usually taken after the second year of a three-year undergraduate degree programme, therefore students usually graduate after four years. In 2014-15, there were 5,770 UK-domiciled first degree entrants on Computer Sciences programmes with a sandwich year, meaning that more than a third of Computer Sciences entrants are enrolled on programmes involving a sandwich placement. Across all STEM entrants, the equivalent proportion is 23 per cent.

5.36 Of the combined 2011-12 to 2013-14 cohort of UK-domiciled full-time first degree Computer Sciences graduates whose course included a sandwich year placement, six per cent were unemployed six months after graduation. This compares to 15 per cent for those Computer Sciences graduates who were not on a sandwich course. Of those in employment only, 25 per cent of graduates who had not been reported on a sandwich course were in a non-graduate role. This compared with six per cent of equivalent graduates whose course involved a sandwich placement. And among those in full-time paid UK employment, 20 per cent of sandwich course graduates were earning less than £20,000 compared to 40 per cent of non-sandwich course graduates.

5.37 An integrated Masters programme provides students with the opportunity to gain a Masters degree qualification, such as an MEng or MSci[46]. The course is usually offered as a four-year (although some students may undertake these programmes as a five-year programme with a sandwich year in industry) undergraduate degree programme with students often progressing to the final year upon successful completion of the first three years of study – although this will differ according to individual HEIs. These programmes provide students with a more in-depth study of Computer Sciences and often include extensive project work. With the exception of a small decrease in 2012-13, numbers of entrants to integrated Masters programmes in Computer Sciences have continued to rise steadily since 2005-06, with 740 new entrants in 2014-15. The large majority of these entrants (580 in 2014-15) were studying at HEIs with high average tariff scores: only 30 were studying at HEIs with low average tariff scores.

5.38 Of the relatively small number of UK-domiciled students who graduated from a full-time integrated Masters degree between 2011-12 and 2013-14, six per cent were unemployed six months following graduation, with 91 per cent either employed or in further study. Of those in employment only, five per cent of integrated Masters graduates were in a non-graduate role. And among those in full-time paid UK employment, 10 per cent of were earning less than £20,000.

5.39 Finally, Figure 13 provides a visual summary of the employment outcomes for each of the groups of students and types of course studied discussed in the previous paragraphs, comparing outcomes for Computer Sciences graduates against the three employment indicators with the outcomes for all STEM graduates.

5.40 The review has considered data available on the outcomes of graduates according to whether a course is accredited or not accredited. Data on whether a course is accredited is only available through information that is provided by HEIs to the KIS. Because institutions return KIS data at course level, and use their own interpretation of a course definition for this purpose, the robustness of the accreditation data is unclear when the data is considered in aggregate at the sector level. This then reduces the review's ability to draw any firm conclusions from it. However, the outcomes of the review's analysis show no significant patterns of improved outcomes for graduates from accredited courses.

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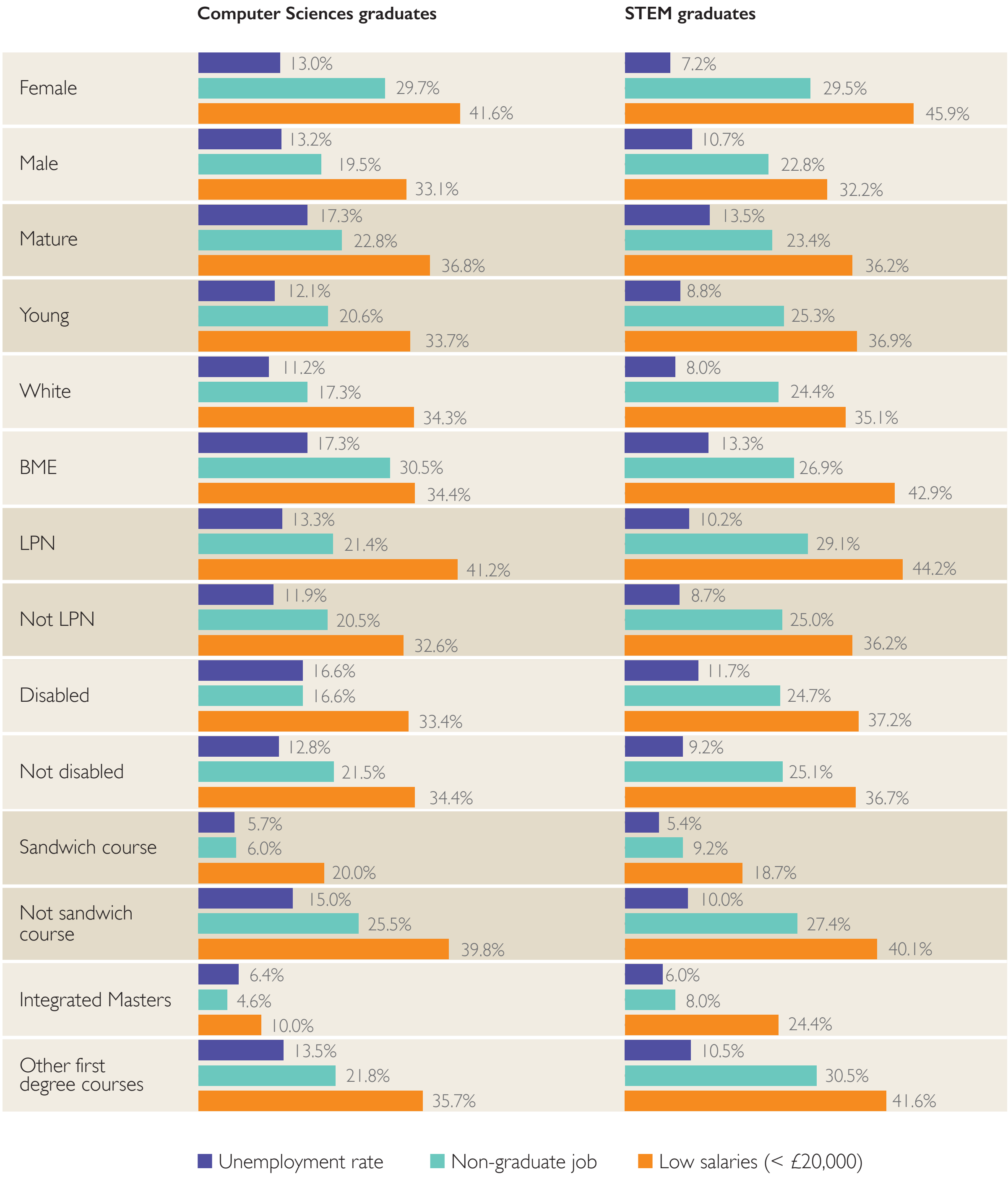
46 Some examples of integrated Masters programmes include: Royal Holloway: https://www.royalholloway.ac.uk/computerscience/prospectivestudents/undergraduate/integratedmasters.aspx, Manchester Metropolitan University http://www2.mmu.ac.uk/study/undergraduate/courses/2016/13180/; and University of Bristol: www.bristol.ac.uk/study/undergraduate/2016/computer-science/meng-comp-sci/

Figure 13 **Employment outcomes of UK-domiciled full-time first degree graduates from STEM and Computer Sciences six months after leaving HE, by student and course characteristics: graduates from publicly-funded English HEIs in the period 2011-12 to 2013-14**



Source: HEFCE analysis of the HESA standard qualifications obtained population at publicly-funded English HEIs, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the DLHE survey six months after leaving HE.

Summary of analysis – supply

5.41 The analysis of destinations data provides an opportunity to present some of the complexities around the employment picture for Computer Sciences graduates. The data shows that, while particular groups or sub-sets of groups of students appear to experience less favourable outcomes than other groups, the patterns and trends are largely consistent with those found among all HE graduates. It also shows that the overall employment outcomes according to the three indicators are not attributable to one particular group or groups of student. However, there are some concerning statistics for the employment outcomes of BME students and for female Computer Sciences graduates six months after graduation.

Demand

5.42 For the purpose of this review, we have considered a range of demand side data, including skills surveys and analysis by the UKCES and the IET together with further interrogation of DLHE data to map the flows of students from study to employment. The analysis in this section therefore continues to look at destinations data to understand where graduates are working and what they are doing, and also presents a summary of demand side data taken from reports drawing on the employer perspective.

5.43 There are limitations on the comparability of employer and HE datasets. For example, it is currently not possible to compare employer data on the desirability of particular skills and the availability of particular jobs with HE sector data on particular numbers of students and their destinations after first degree study. Analysis of DLHE data is presented according to the Standard Occupational Classification (SOC) and Standard Industrial Classification (SIC), which is used in UKCES surveys and reports. The value that planned HM Revenue and Customs data linked to student records may add is not yet known in terms of better understanding the nature of employment gained by HE graduates, but it may prove complementary to existing analysis based on SOC. In addition, the SOC is helpful in understanding at the broadest level what jobs graduates are doing, but is not designed to adequately capture the actual skills that employers are asking graduates to do in those roles and is limited in the extent that new skills and roles can be adequately described. It is also limited in its applicability to modern job roles that have emerged in the digital and technology-driven economy. Having acknowledged these issues, the review therefore continues to draw on a range of data available in related reports to attempt to present a picture of the demand for Computer Sciences graduates.

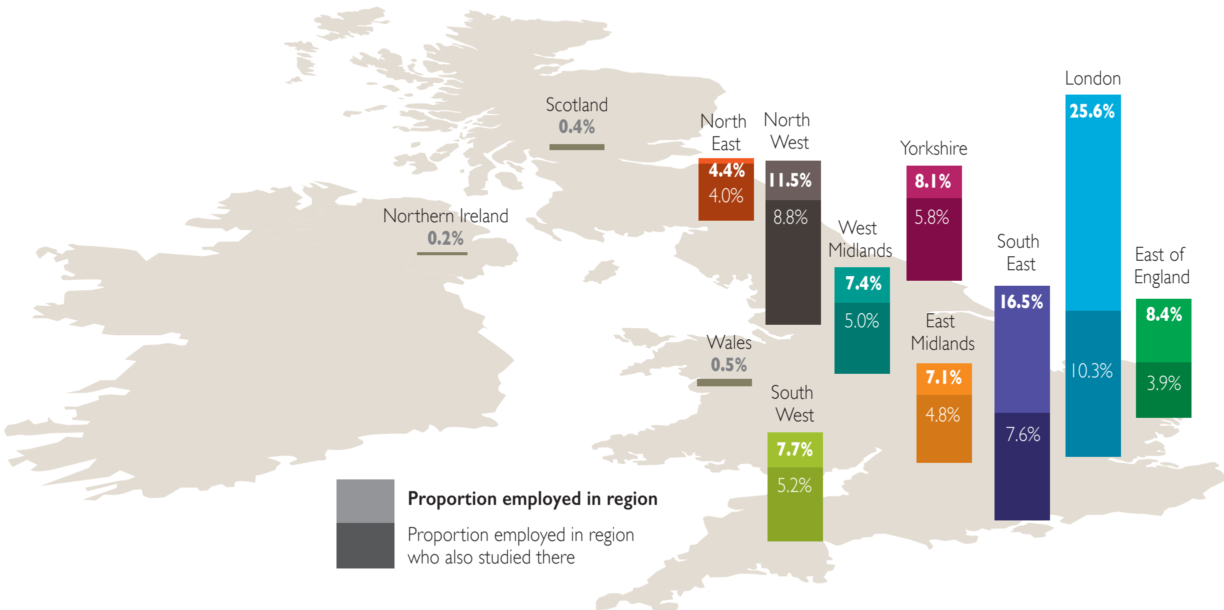
5.44 Destinations data from the DLHE survey provides some interesting insights into the demand for Computer Sciences graduates by location. Analysis of the DLHE data across three cohorts (from 2011-12 – 2013-14) of graduates has enabled the review to show where in the UK graduates from Computer Sciences courses go onto find employment in computer science related graduate level roles. We can also understand how many graduates find employment in the same region where they studied Computer Sciences. By considering where graduates move to get jobs, we can begin to build a picture of where, in England, graduates are in demand and how this may impact on the employment outcomes of graduates from certain backgrounds and from particular parts of the country. Interactive maps will shortly be published by HEFCE which will enable the user to understand more about where particular types of Computer Sciences graduates find work. However, for the purposes of this review, we present information about employment in graduate level roles for four groups of Computer

Sciences graduates: all Computer Sciences graduates, Computer Sciences graduates from LPNs, BME Computer Sciences graduates, and Computer Sciences graduates whose course included a sandwich year. The maps show the overall proportion of Computer Sciences graduates who found employment in a computer-science related, graduate role. They also show the proportion who both studied and found employment in that region (shown in the darker shading).

5.45 As we know, Computer Sciences is taught at the large majority of HEIs. Its students are therefore graduating from these programmes across the country, where they enter into both a local and national employment market. Map 1 below shows that a quarter of those UK-domiciled full-time first degree Computer Sciences graduates from publicly-funded English HEIs who took up full-time paid UK employment in a computer science-related[47] graduate role did so in London. Of these, 10 per cent of graduates had both studied and then found work in the city. The South East more broadly is a destination for many Computer Sciences graduates. However, Map 1 also shows graduates working in other cities and regions, including the East Midlands and major northern cities, including Manchester and Leeds.

5.46 The review has also looked at where graduates go on to take up employment based on their background to see if there are any variations to the overall picture. Map 2 shows that, for those Computer Sciences graduates who came to HE from areas where there are comparatively fewer young people who go onto study at HE level – or Low Participation Neighbourhoods (LPNs) – the maps show that these graduates are less likely to move to London for work following graduation – with just over 12 per cent who have studied Computer Sciences and entered full-time paid UK employment in a computer science-related graduate role moving to London for work. Of these only 3 per cent had both studied and were employed in the capital. In contrast, of the 15.8 per cent who were employed in the North West, 12.5 per cent also studied there. Again, employment destinations for these graduates is spread across the country.

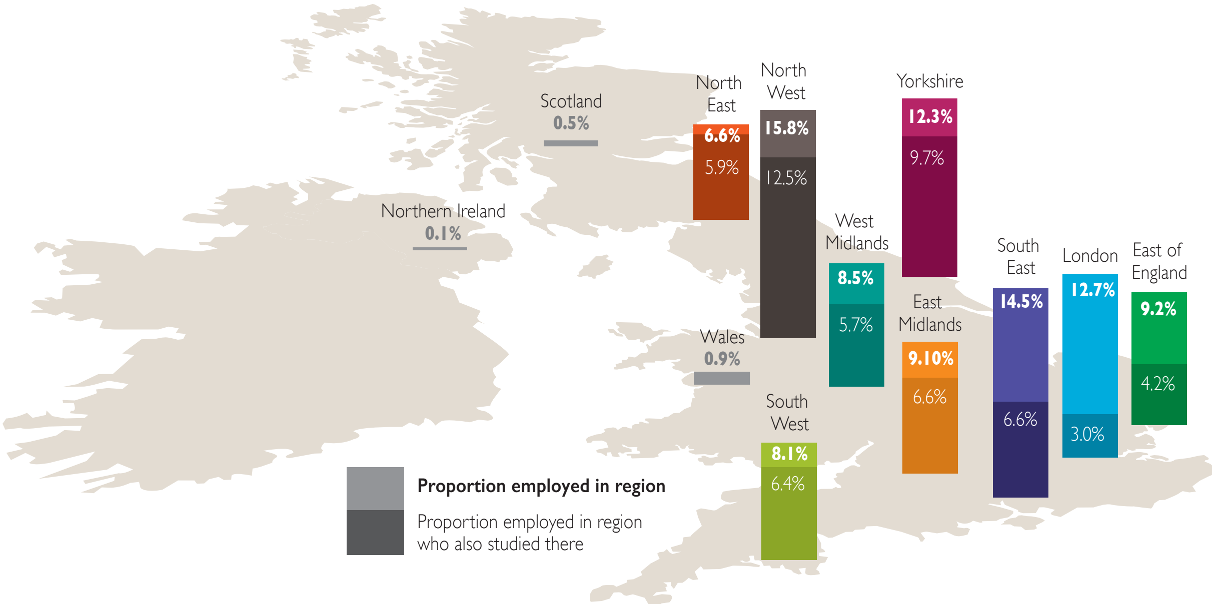
Map 1 – Employment locations for UK-domiciled full-time first degree Computer Sciences graduates six months after leaving HE: from publicly-funded English HEIs, 2011-12 – 2013-14



Source: HEFCE analysis of the HESA standard qualifications obtained population, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the Destinations of Leavers from Higher Education (DLHE) six months after leaving HE.

47 Roles have broadly been classed as computer science-related by considering SOC data and SIC categorisation 'Information and communications industry'

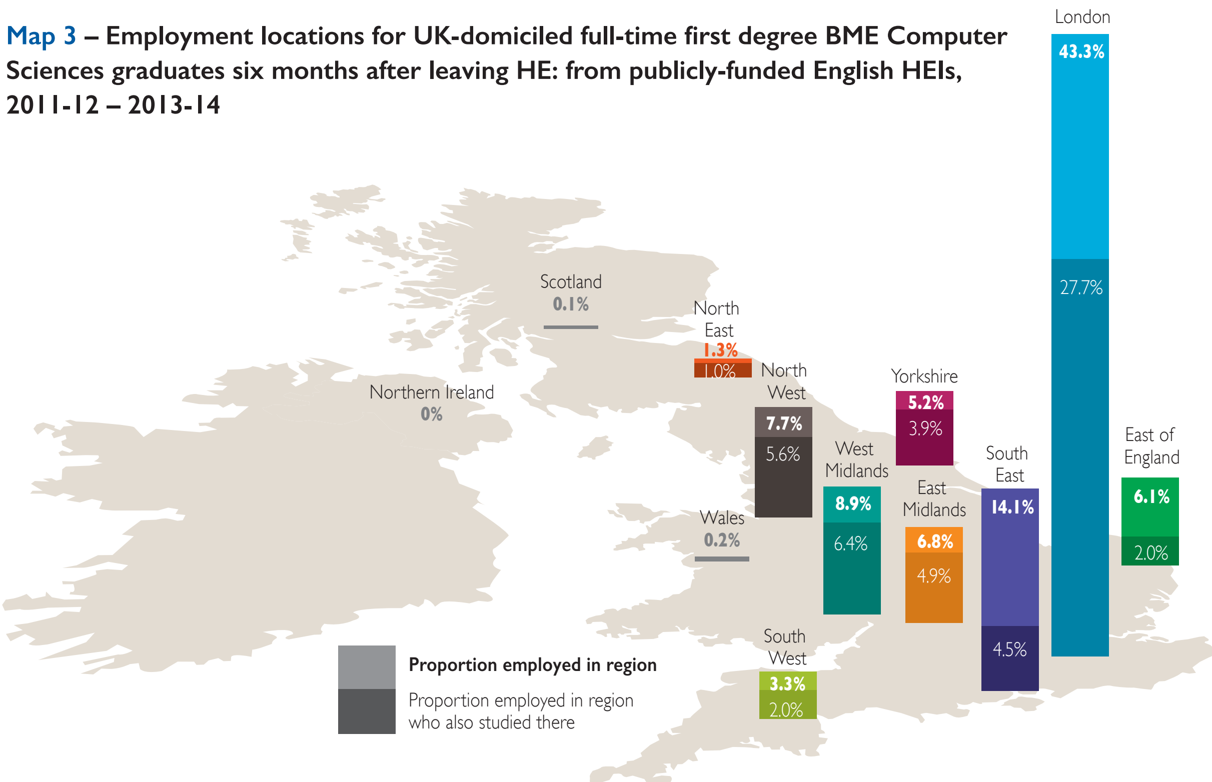
Map 2 – Employment locations for UK-domiciled full-time first degree Computer Sciences graduates from Low Participation Neighbourhoods (LPNs) six months after leaving HE: from publicly-funded English HEIs, 2011-12 – 2013-14



Source: HEFCE analysis of the HESA standard qualifications obtained population, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the Destinations of Leavers from Higher Education (DLHE) six months after leaving HE.

5.47 For BME students, London is a popular location to both study and work; Map 3 shows that nearly 28 per cent of Computer Sciences graduates from BME backgrounds who entered full-time paid UK employment in a computer science-related graduate role found employment in the capital, having also studied there. But many BME students also move there when they graduate – overall, just over 43 per cent of BME graduates found employment in London. Birmingham is also a popular location for BME graduates.

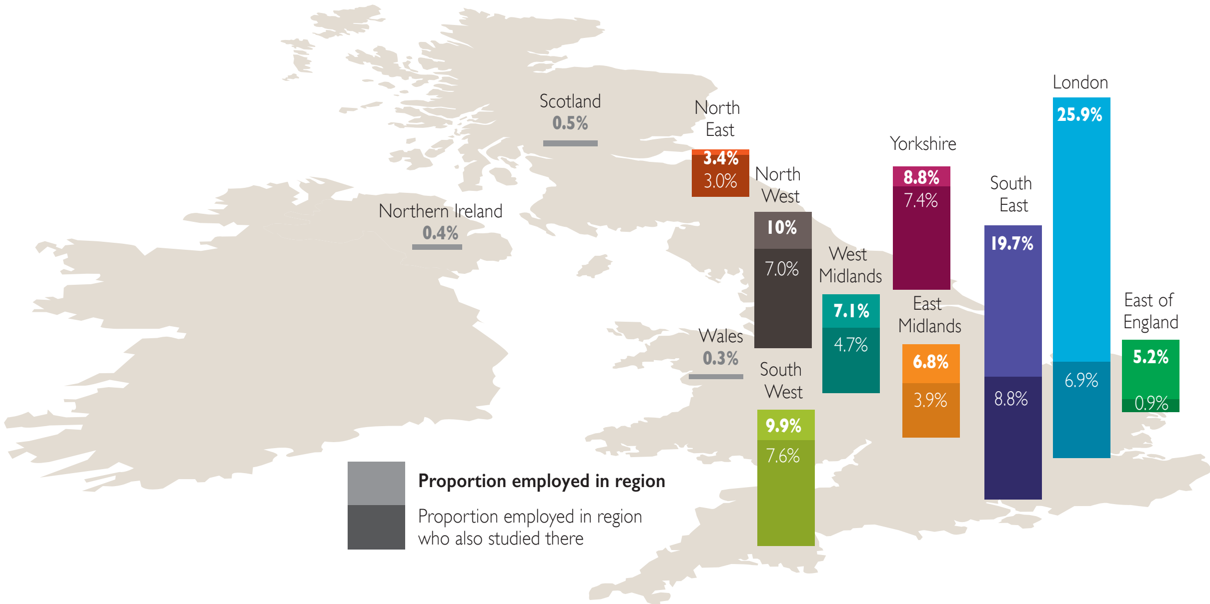
Map 3 – Employment locations for UK-domiciled full-time first degree BME Computer Sciences graduates six months after leaving HE: from publicly-funded English HEIs, 2011-12 – 2013-14



Source: HEFCE analysis of the HESA standard qualifications obtained population, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the Destinations of Leavers from Higher Education (DLHE) six months after leaving HE.

5.48 Evidence presented in the previous section showed that graduates from sandwich year degree programmes had better employment outcomes than those who were on courses without a sandwich year. The destinations data shows some subtle differences in the spread of employment across England for those students who undertook a sandwich year and entered full-time paid UK employment in a computer science-related graduate role. Map 4 shows that while the largest proportion of these students take up employment in the capital (26 per cent), which follows the overall trend for Computer Sciences graduates, the data shows that these students are employed across the country. Similarly to LPN students, a significant proportion of Computer Sciences graduates who studied in the North West, also found employment there. This is similar for those that both studied and were employed in the South West and in Yorkshire. This may be evidence that these students are more employable to a wider range of employers. But may also show that students have linked with a broader range of employers outside of the South East during their sandwich year and that they may then go on to take up a permanent role with those employers when they graduate.

Map 4 – Employment locations for UK-domiciled full-time first degree Sandwich Course Computer Sciences graduates six months after leaving HE: from publicly-funded English HEIs, 2011-12 – 2013-14



Source: HEFCE analysis of the HESA standard qualifications obtained population, 2011-12 to 2013-14. Graduates who subsequently provided a valid response to the Destinations of Leavers from Higher Education (DLHE) six months after leaving HE.

5.49 Having considered where in the country Computer Sciences graduates are employed, we now turn to consider surveys of employers to try to build a picture of industrial demand for Computer Sciences graduates.

5.50 The 2014 UKCES Employer Perspectives Survey found that 81 per cent of employers found university graduates from all subjects to be well prepared for work. In instances where employers indicated they were poorly prepared, this was attributed to a lack of work experience or experience of working life. Of those surveyed, the report found that relevant work experience (for all candidates, regardless of educational attainment), was rated as 'critical or significant' by two-thirds of UK employers. The report also noted, however, that those who valued work experience as critical or significant were only slightly more likely to offer work placements than those who did not value this factor as highly.

While the report highlighted the emphasis placed on work experience, it also demonstrated an upward trend in employers seeking academic qualifications. Indeed, for many of the industries where Computer Sciences graduates are going on to get jobs, such as financial and business services and education, the UKCES survey found that academic qualifications are viewed as more critical or significant than work experience. This type of evidence reinforces the variety of views within and among employers and highlights the challenges associated with developing an understanding of the types of skills and experiences that businesses want from graduates.

5.51 We already know that Computer Sciences graduates enter a range of industries, as Figure 14 demonstrates. This shows where Computer Sciences graduates are employed according to the Standard Industrial Classification. While the largest proportion of graduates enter roles in the Information and communication industry (around 43 per cent), a substantial number also go on to get jobs in Wholesale and retail trade (9.4 per cent); Professional, scientific and technical activities[48] (8.6 per cent); Finance and insurance (8.1 per cent); Manufacturing (7.3 per cent); Education (5.5 per cent), and Administrative and support service activities (4.4 per cent).

5.52 In the UKCES Sector insights publication, *Skills and performance challenges in the digital and creative sector* (2015) there was a mixed response from employers when asked whether a Computer Sciences degree was important to meet some of their current and future skills needs. The report suggests that 'some' employers placed more emphasis on an individual's ability to learn while others felt Computer Sciences graduates '*have a better understanding of programming languages, enabling them to quickly learn new languages as they emerge*' (pg.65). This balance between graduates possessing the 'latest' skills to match the immediate needs of employers, while having mastered the fundamental principles underpinning Computer Sciences, was a common theme debated at the Westminster Higher Education Forum held on 11 February 2016 to discuss employability issues for Computer Sciences graduates. Here it was argued that with a fundamental understanding of the discipline, a Computer Sciences graduate will have the aptitude to understand the disparate and varied technical infrastructures of different employers and will better prepare them for a long career that will likely see significant change in different industries while working with several different employers[49]. The specific example of technology behind a mobile phone operating system was presented to the Forum – where Symbian, a dominant technology, was quickly supplanted by a new generation of quite different operating systems.

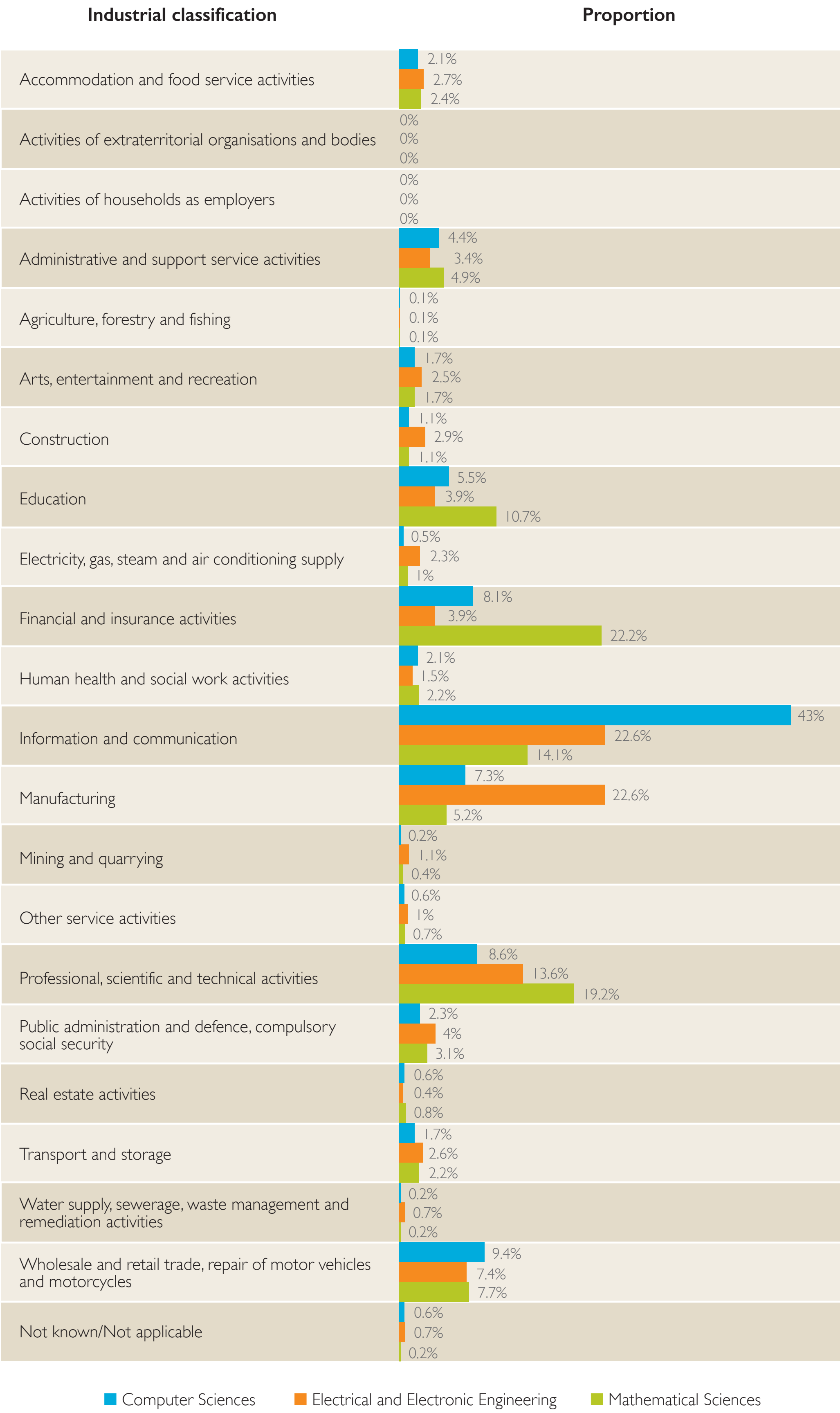
5.53 A 2014 report by EEF, the body that represents UK manufacturers, found that the manufacturing industry was taking action to address a potential future skills gap by working more closely with higher education. The report, *Improving the quality and quantity of graduate level skills*[50], found that 64 per cent of manufacturers had recruited a graduate in the past three years and, while the most in demand graduates were those with an engineering-related degree, other STEM disciplines were in demand, particularly Physical Sciences and Computer Sciences.

48 For more details on the SIC, please see: https://www.hesa.ac.uk/content/view/102/143/1/11/

49 Presentation by Dr Steve Pettifer, Reader and Director of Teaching Strategy, School of Computer Science, University of Manchester

50 https://www.eef.org.uk/resources-and-knowledge/research-and-intelligence/industry-reports/improving-the-quality-and-quantity-of-graduate-level-skills

Figure 14 **Proportion of full-time first degree Computer Sciences graduates employed by Standard Industrial Classification (SIC)**



5.54 The 2015 CBI report, *Inspiring growth: Education and skills survey*, states that graduate recruitment remains strong, with the biggest growth in engineering, science and hi tech industries. The report also states that employers find STEM graduates more attractive than non-STEM graduates, although an individual's attitude and aptitude was the most important consideration for employers. The survey indicates that, overall, while businesses are satisfied with the technical skills of graduates, they are dissatisfied with a range of soft skills and commercial awareness, such as team working, business and customer awareness.

Summary of analysis – demand

5.55 The exact nature of demand from employers is difficult to establish based on current evidence available, but surveys and reports available do provide a clear indication that STEM graduates, including those from Computer Sciences, are well regarded by employers. However, all employers are increasingly looking for individuals with soft skills and business awareness in combination with technical skills. The growth of the digital and creative sector will, in particular, require graduates with a high level of technical skills who are able to understand the practical application of those skills to commercial and client-facing contexts. However, a high level of demand for these types of graduates is also being witnessed within professional and managerial occupations, in science, research, engineering across both 'traditional' technology-driven and non-technology industries. The evidence highlights Computer Sciences graduates are finding well paid, graduate-level employment in computer-science related roles across the country, indicating that demand exists outside of the capital, but it also highlights that there are variations in the patterns of these movements according to different groups of students.

6 What the data tells us – qualitative analysis

6.1 The data presented in the previous chapter provides a picture of the employment outcomes of graduates and attempts to present an idea of what demand looks like from employers. Destinations data through the DLHE survey can provide some indication of how different types of degree programme can impact on a graduate's employment outcomes, but it will only tell part of the story. The review therefore conducted further qualitative evidence-gathering to try to understand in more detail: the demand-side perspective – what do employers of Computer Sciences graduates want from their recruits and is this realistic; the supply-side perspective – what do graduates of Computer Sciences think about employer expectations and about their degree; how do HE providers feel their courses are meeting the needs of employers; and the role of accreditation and its accrediting bodies in employment outcomes. The outcomes of this evidence-gathering is presented below.

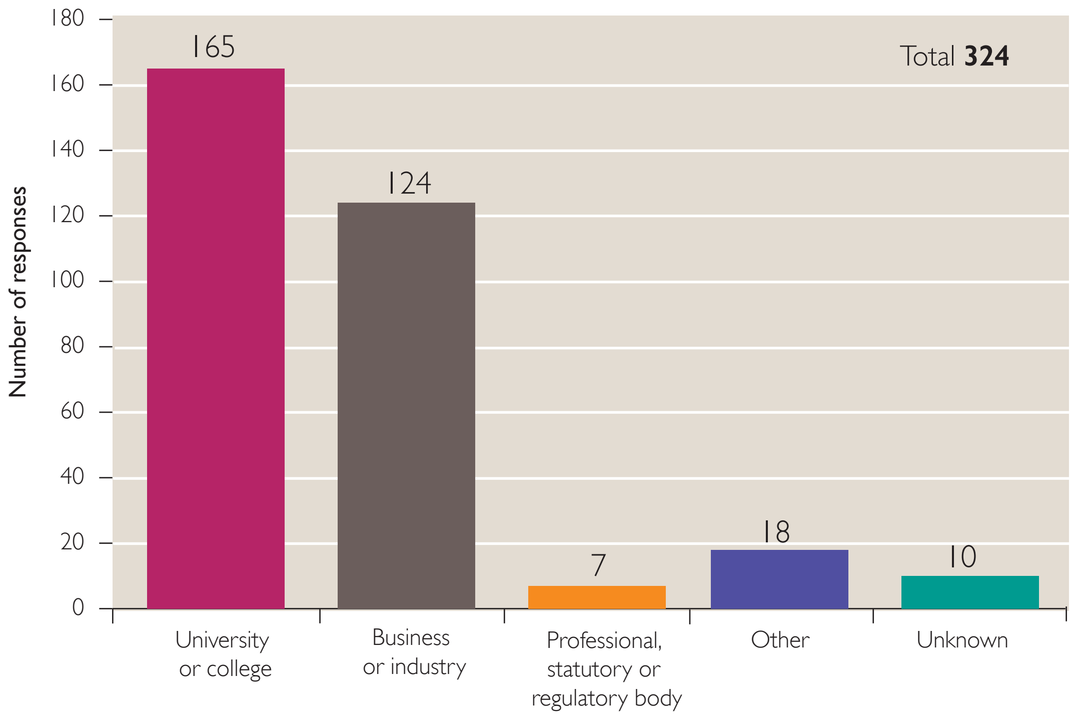
Stakeholder survey

6.2 The review held an open consultation in the form of an online survey which invited stakeholders to contribute their views on graduate employment outcomes for Computer Sciences students. The survey aimed to capture a wider and more contextual understanding of the complexities of the graduate employment situation for Computer Sciences graduates.

6.3 The survey ran for seven weeks in July and August 2015 and received a total of 324 responses. A copy of the survey is available at Annex G.

6.4 Overall, responses represented a reasonable mix of stakeholders. While a majority of responses received were from universities and colleges, referred to collectively in this report as HE providers, there was also a significant response rate from business and industry as Figure 15 shows.

Figure 15 **Stakeholder survey responses by type of stakeholder**

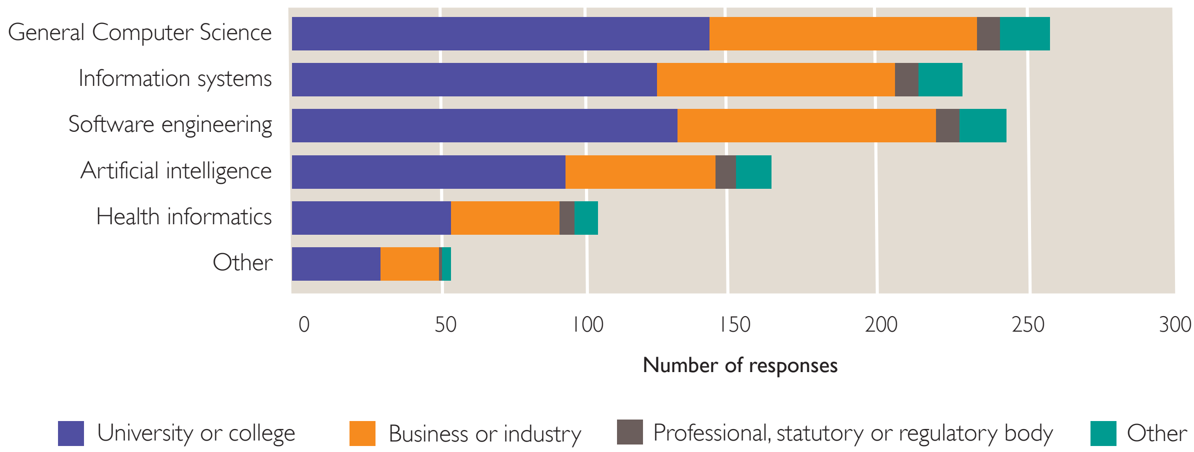


6.5 Respondents were asked to comment on the employability of Computer Sciences graduates according to the following broad subject areas defined by HESA: General Computer Sciences; Information Systems; Software Engineering; Artificial Intelligence; Health Informatics. Based on these responses, survey respondents appeared able to comment on a wide range of areas within Computer Sciences, as Figure 16 demonstrates.

6.6 All respondents were invited to answer general questions, followed by a series of specific questions, including sets of specific questions for HE providers, and business and industry. This enabled an analysis of the particular issues for these stakeholders.

6.7 Overall 58 per cent of respondents agreed that Computer Sciences graduates were meeting the needs of employers[51]. However, when examining how different stakeholders responded to this question, there were some differences in opinion. Respondents from business and industry and PSRBs were less positive about graduates meeting employability requirements of employers than those from HE providers. The overall response to this question aligns well, indeed is almost identical, with a parallel survey conducted to support evidence-gathering in the Wakeham Review. This showed that more than 60 per cent of respondents agreed that STEM graduates were meeting the employability requirements of employers.

Figure 16 **Responses to stakeholder survey question about whether graduates meet the needs of employers by area of interest**



6.8 When considering what might enhance graduate employability, respondents felt that institutional and departmental engagement of universities and colleges with business and industry leads to enhanced employability. A significant majority of business and industry respondents (95 per cent) agreed that industrial experience leads to enhanced employability of graduates. Just over 90 per cent of respondents from business and industry agreed that different course syllabuses have different employability outcomes – this compares with just under 70 per cent of HE providers.

51 The survey asked – 'To what extent do you agree that recent graduates meet the employability requirements of employers?'

6.9 Each respondent was asked to identify up to three main issues which they thought impacted on graduate employability. Overall the main issues identified were:

- Graduates lacking 'softer' skills
- Graduates lacking specific knowledge
- Graduates lacking computer programming skills or specific programming languages
- Graduates lacking business/commercial awareness
- Graduates lacking work experience

6.10 With the exception of computer programming skills and languages, these key issues align with those identified in the parallel survey conducted for the review of STEM provision and employability. They also align with the findings of the UKCES and CBI surveys outlined earlier in the report.

6.11 In some cases only a small number of a particular type and size of business responded to the survey. For example, a very low number of responses were received from organisations providing IT hardware and communications, as well as those engaged in computer science research. Therefore the extent to which we can draw firm conclusions about the views of particular types of employer is limited. However, broadly speaking, there was a good range of different employer types that responded to the survey with the majority of respondents from IT software and services, followed by users of IT systems and services. The majority of business respondents were from organisations with 1,000 or more employees, with around a quarter of business respondents from businesses with 49 or fewer employees. The majority of businesses who responded to the survey recruited fewer than ten graduates annually.

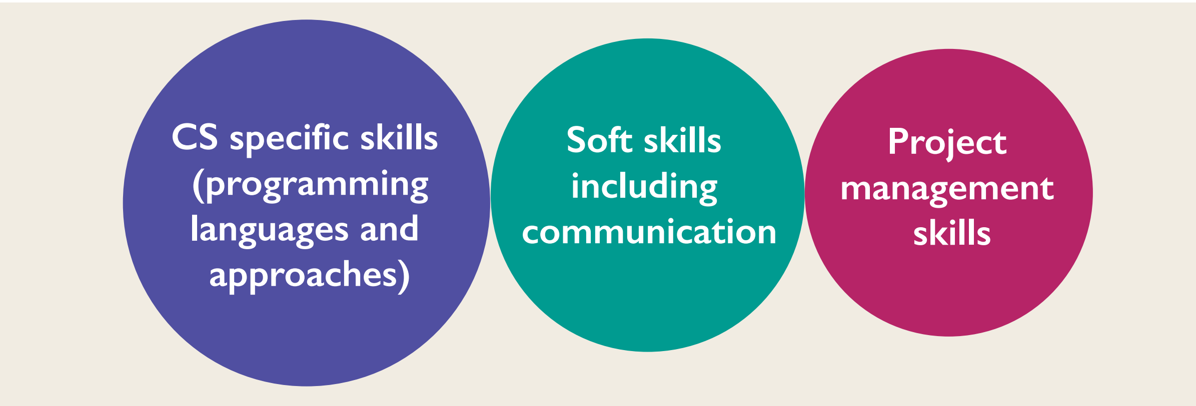
6.12 A more detailed analysis of the responses from business and industry about how well Computer Sciences graduates were meeting employability requirements of employers showed that, broadly, those organisations who identified themselves as engaged in computer science research and those who identified themselves as users of IT systems and services were more positive about the 'quality' of graduates. Those organisations who identified themselves as providers of IT software and services, or hardware and communications were less positive. It should be noted again that the number of responses received for each of these different types of business varied considerably so these results may not necessarily be representative where response numbers were low (e.g. IT hardware).

6.13 However, it is still interesting to examine the differences in opinion from employers who identified themselves as users of IT systems and services, and those other employers who identified themselves as providers of IT and computer science solutions. The results show that 'users', for example Human Resources departments within banks or similar organisations, are more positive about graduates than the 'providers', for example companies that develop software. Similarly, large organisations seemed broadly more positive than small organisations. It is important to note that a relatively small number of responses were received from organisations with 50 to 249 employees and those with 250 to 999 employees. Engaging satisfactorily with smaller firms throughout the review has been challenging.

6.14 Respondents from business and industry were asked what skills should be possessed by Computer Sciences graduates to better meet their needs. The majority indicated work readiness in the form of specific computer science skills, such as programming languages. However there was a wide range of views in relation to this particular technical area. Some employers rejected the need for graduates to know particular languages, arguing that it was more important for graduates to possess an ability to learn, recognise, differentiate and select relevant languages for a particular task than simply to know the 'latest' languages. This points to the importance of the conceptual underpinnings of computer science being present in any curriculum.

6.15 Employers were also looking for graduates with knowledge of computer science work approaches. More broadly, employers indicated they wanted Computer Sciences graduates to possess a range of soft skills including communication and team working. The range of skills that employers are looking for was reflected in employer responses. Figure 17 shows the top three skills that were most commonly cited in responses from employers.

Figure 17 **Responses to stakeholder survey question about the types of skills desired by employers – Top 3 most commonly cited**



6.16 HE providers were specifically asked what evidence they capture of students' work experience. The majority of respondents indicated that they captured evidence in some form, but usually this was limited to formal placements.

Accreditation

6.17 The survey asked specific questions to all respondents about their views on the current accreditation systems for Computer Sciences undergraduate degree programmes. On the whole, respondents felt degree accreditation added little value to graduate employability[52], with only 36 per cent responding that it enhanced employability. This majority response reflects the views of respondents from HE providers, businesses and industry, within which there was little difference of opinion. Those identifying themselves as PSRBs seemed broadly more positive about accreditation, but this necessarily represents a small group of respondents.

52 Respondents were asked – 'To what extent do you agree that current accreditation of courses in Computer Sciences enhances graduate employability?'

6.18 A similar question was asked in the survey conducted for the Wakeham Review. It asked respondents from HE providers only to indicate the extent to which they felt various 'quality systems and processes' had an impact on graduate employability. HE providers indicated that, of the range of systems and processes, including external examiners and external benchmark statements, it was professional accreditation systems that had the highest impact on graduate employability. In addition, when examining only those responses to the STEM survey where the respondent had indicated they had an interest in Computer Sciences, the pattern remains very positive. This is in marked contrast to views expressed in responses to the survey conducted for this review.

6.19 Respondents were asked what benefits accreditation brought to their organisation and to the profession as a whole. A large number of responses felt that accreditation brought no benefits; this was a strong message both from HE providers and employers, and in many cases the particular point was made that it did not impact on employability of graduates.

6.20 Employers' lack of awareness of course accreditation was also highlighted here, reinforcing the view from earlier questions that business and industry do not always understand its role or purpose. A number of key positives were identified in the survey, but in some cases it was not explicitly clear whether these were benefits brought by the current accreditation system, or ideas about what benefits accreditation could bring. The key benefits of accreditation that were identified though the survey were:

- It provides a guide to standard course content or a reliable gauge of skills
- It gave an indication of HE sector quality assurance expectations or an external quality benchmark
- HE providers felt it is a benefit to student recruitment or course marketing
- It could improve employability if it provides business/soft skills
- It allowed for industry involvement in course content

6.21 Negative aspects of the current accreditation system were identified as:

- It has limited or no impact generally
- It has limited or no impact on employment prospects
- The institution itself is more important to employers
- Employers have a lack of awareness about accreditation

6.22 Respondents were also asked how the current regime for accreditation of Computer Sciences degrees could be improved. Key suggestions were:

- Greater engagement with industry, both by the accrediting bodies and by the HE sector in general. It was noted that achieving better 'buy-in' from employers would be important in ensuring that they understood and valued course accreditation.
- A more efficient accreditation process would be particularly welcomed by HE providers (this was the most important issue for such stakeholders).

- An accreditation process which facilitated improvements in curriculum design would be welcome (this was a key issue both for HE providers and for employers).
- Differentiated accreditation standards for different types of Computer Sciences courses was a key theme, recognising that there is a wide variety of courses and curricula available and that a 'one size fits all' approach to accreditation could not support such diversity.

6.23 Respondents from business and industry did not feel their organisations valued course accreditation in recruitment processes. When asked how accreditation systems can ensure that degree course content is up-to-date and relevant to the needs of industry, the majority of responses suggested employer engagement in accreditation was a key factor, followed by alignment of course content with business needs, and improved relationships between HE and industry.

Focus groups

6.24 Themes that emerged from the stakeholder survey were used to inform three focus groups held in October and November 2015. The focus groups considered: supply and demand; the nature of the skills gap; and the role of accreditation. Attendees were from a range of organisations including representatives of HE providers, business and industry (including SMEs and larger corporations), PSRBs and other representative organisations. Annex H provides a list of attendees. The focus groups allowed the review to explore in more depth themes emerging from both the stakeholder survey and the destinations data. Key findings arising from the focus groups are considered alongside wider review findings and presented below.

Supply, demand and the skills gap

6.25 Evidence gathered throughout the review demonstrates that the nature of demand for Computer Sciences graduates will change to reflect the fast pace of change in the technology and digital sectors. However, identifying, articulating and measuring the skills 'gap' is not straightforward. It is complicated by several factors including: a lack of data and information about demand; the different skills requirements of different organisation types; and the range of courses and therefore graduates with different skill sets offered under the banner of IT and Computer Sciences. This is all the more challenging when attempts at capturing these skills needs are occurring in an environment characterised by disruptive, fast-paced innovation.

6.26 However, focus group discussions assisted in highlighting the distinction between a need for 'deep' technical skills and a need for broader, softer skills crucial for working in teams, developing successful working relationships and contributing positively to an employer's strategic vision. In terms of technical skills, the evidence gathered indicates that future areas where Computer Sciences graduates will be in demand include embedded infrastructure, security, big data, network analytics and finally design – which, while small in terms of numbers of employers, is significant in terms of its economic impact. Common skills required of all Computer Sciences graduates include: an understanding of core computer science concepts, which indicates an ability to learn and adapt to new computing environments. These core concepts include: algorithm design, complexity analysis, data analytics, elements of artificial intelligence and machine learning, distributed systems, fundamentals of operating systems, user centred design, validation and verification methods. They also include a wider appreciation of the context within which computer science sits, including areas such as business and commercial awareness; understanding of legal and economic issues surrounding Computer Sciences, including privacy and licensing; testing; an ability to meet customer needs (and therefore an understanding of meeting deadlines and budgets); and knowledge of organisational structures. An ability to pursue ongoing learning and development was also deemed highly important. These findings align with those suggested in wider reports by the UKCES and at the European level.

6.27 Both the stakeholder survey and focus group discussions highlighted the diversity of employer needs but also expectations. Larger corporations may be more likely to want to 'mould' their new graduate to fit their organisation, and evidence gathered during the review indicates that large multinationals are prepared to invest in their new recruits to get the individual they want. Many of these larger employers tend to interview graduates on the assumption that their degree courses have provided them with the requisite foundational knowledge and skills, and instead seek to differentiate graduates on the basis of a wide range of other skills that are linked to employability, such as soft skills.

6.28 In contrast, SMEs are looking for highly skilled graduates, but an SME is both less likely and less able to commit valuable resources (both in terms of time and money) to get the graduate it needs to fit its business at a particular time in its business cycle. SMEs also risk losing graduates to better paid and more secure roles in larger or more established companies. Start-ups may employ very highly skilled and capable graduates but who may lack skills and experience in business and entrepreneurialism to ensure the long-term success of their business and the security and development of their employees.

6.29 Discussions during the focus group and responses to the stakeholder survey indicate that employer expectations may sometimes be unrealistic, with many expecting graduates who were 'oven ready', or able to 'hit the ground running'. There is a clear sense that HE providers feel their role is to prepare students for a life of learning through developing capabilities and analytical capacities rather than to meet the demands of particular businesses. As one survey respondent argued:

> '*Employers expect graduates to have been exposed to these [specific technologies] and it is not a realistic assumption (we are not training their staff)*.' (Head of Computer Sciences Department, UK University).

6.30 In contrast an employer argued that:

> '*Computer Science courses can be quite generic, and therefore we spend quite a lot of time and money on training for particular technology or skills.*' (CEO, Industry).

6.31 Another stated that:

> '*We struggle to attract graduates who have skills suited to embedded systems software development. We are concerned that courses focus on Computer Science as an IT / data-centre / desktop domain, rather than looking at general software development.*' (R&D team lead, Industry).

6.32 Computer Sciences is constantly evolving making it difficult to identify the exact nature of the demand for skills from employers. As is evidenced in this response from an employer:

> '*Lack of knowledge in the latest technology – taught irrelevant languages for today's environment – Java is not what it once was!*' (CEO, Industry).

6.33 This contrasted with another employer who stated:

> '*HE is trying to "keep up" with the latest languages/fads and teach a limited set of specific languages. We would prefer a broad set (aim to teach 10+ languages), so that students can compare/contrast, understand the principles behind languages and therefore be able to adapt to new languages/technology.*' (Director, Industry).

6.34 Employer needs vary by region, which impacts both graduate employment opportunities and work experience options during the course of their degrees. This is supported by evidence from the destinations data which shows that, while London is the main destination for Computer Sciences graduates, there are strong areas of recruitment across the UK which better suit students from backgrounds or in situations where moving for a job is not always possible or desirable. This point was echoed by focus group attendees, who cited regional employment initiatives as both a source of graduate employment and of work experience placements and engagement with industry more broadly. These 'clusters' are also a focus of the *Tech Nation 2016* report.

6.35 Focus group discussions and the findings of the stakeholder survey support the view that we need a spectrum of degree programmes to continue to meet the needs of industry, but the supply of certain skills (in graduates) should more accurately reflect demand (from employers).

6.36 Evidence gathered during the review points strongly to the value of engagement between HE and employers. The UKCES Employer Perspectives Survey 2014 found that 36 per cent of employers who responded believed HE providers were not interested in engaging with them and 28 per cent cited difficulties with initially communicating with HE providers. Discussions in the focus groups acknowledged there were difficulties that arose through differences in language and terminology, as well as a lack of understanding of processes within HE providers. Differences in the terminology used to describe job roles, and how the skills required to do those job roles differed, also created problems when HE providers and employers were actively engaged with each other. Evidence from this review supports the finding and recommendation from the *Review of publicly funded digital skills qualifications*, that there should be consistency and clarity of language. For this review this relates to a common terminology that students, HE providers and employers could share and understand.

6.37 The volume and breadth of degree programmes which fall within the Computer Sciences broad subject grouping also presents difficulties for employers in assessing whether a student has a particular skill. This can lead to employers relying on existing knowledge of, or relationships with, specific HE providers when recruiting graduates. The impact of this issue was highlighted in the final report from the 2015 National Union of Students (NUS) *Commission on the Future of Work*[53], which found that graduates (across all subjects) were potentially being disadvantaged by recruitment processes that created a barrier to employment. The practices highlighted in the report include applications being sifted by A-Level tariff, degree classification and by '*institutions that were "preferred" by employers*' (pg.15). The UKCES Employer Perspectives Survey (2014) also found that 30 per cent of employers who responded to the survey used word of mouth and personal recommendation as a recruitment channel.

6.38 Evidence also suggests that some HE providers are better than others at helping students to research, apply for and gain work placements. Some Computer Sciences departments have staff dedicated to employability such as the Placement and Employability Team at Sheffield Hallam University[54] and staff who oversee engagement with partner employer consortia at the University of the West of England (UWE)[55]. The review's evidence has clearly indicated the value of work experience (including placements and internships) to enhance graduate employability. For industry, placements provide the opportunity to 'try before you buy'. Although, again, there are differences for organisation type: SMEs may prefer a shorter placement to reflect the cost to their company and reduce risk; large organisations will have the resources to invest in the individual over a longer period.

6.39 While the benefits of work experience are clear, the review has heard evidence to caution that this is not the only solution to poor employment outcomes. A mechanism may be needed to both identify and then transfer the benefits arising from work experience to students who are unable to undertake placements. Better information is therefore needed on the outcomes of graduates who undertake different types of work experience, including the skills they have gained during their work experience and how these contributed to a successful employment outcome. A better understanding is also needed on the take up of placements across HE providers.

6.40 Degree apprenticeships were raised during focus groups as a way of providing graduates with on-the-job training; however there was some caution over the potential lack of transferability for a graduate who had trained at a particular organisation and developed a specific set of skills.

6.41 Our focus groups provided a forum for HE providers and industry, and this highlighted the mutual desire for better and more meaningful engagement between HE and its students and industry. Such engagement should aim to: develop a common language and understanding of skills needs (as outlined in more detail in paragraph 6.36); to provide a more practical input to the curriculum and in assessing learning outcomes, and to assist students in successfully entering graduate roles. This might be achieved through refocussing

53 www.nusconnect.org.uk/resources/commission-on-the-future-of-work

54 https://students.shu.ac.uk/aces/placements.html

55 http://www1.uwe.ac.uk/et/csct/aboutthedepartment/studentexperience/workplacementemployability.aspx

students on business needs by: challenging current industry advisory boards to be more than a talking shop; identifying a trusted/respected advisor/critical friend from industry to provide informal input to assessments, including presentations; making better use of alumni to mentor and speak to students and develop industrial links with their institution; providing work placements, shorter industry-relevant projects and competitions where the aim is to meet the needs of the customer.

6.42 The evidence gathered in the focus groups highlighted how students can enhance chances of employment by better understanding, recognising and cataloguing their transferable skills. For example, evidencing problem solving, and abstract as well as systems-level thinking. Students need to be better at 'selling' themselves. This can be supported by the HE provider through improving careers advice. For example, CV workshops; developing interview techniques; increasing awareness of the jobs market; using alumni as mentors.

Accreditation

6.43 Many of the findings from the stakeholder survey were supported by discussions at the focus group held to discuss accreditation. While HE providers felt it was valued as a mark of quality and provided assurance, particularly to senior managers in HE providers, it was accepted that it was poorly understood, particularly by students and employers. The focus group highlighted that the current accreditation process is too cumbersome, monolithic and detailed, and emphasises process over quality of content.

6.44 The focus group provided an opportunity to discuss how a future accreditation system might be improved. Suggestions at the group included:

- Raising the profile, status and value of accreditation in partnership with industry, accrediting bodies and HE providers.
- Enabling a debate about professional registration for particular computer science sectors. This idea was also discussed in a roundtable with Royal Society fellows, where the liability of individuals who were using their computer science skills in for example, safety critical systems, such as flight equipment, was discussed.
- A simpler 'quality mark' is needed which is easily recognisable and competency-based.
- Ensuring that the autonomy of HE providers is protected to guard against introducing too great a degree of commonality to degrees.
- More frequent, light touch accreditation to enable changes to courses (and facilities) would be welcomed. This flexibility would then reflect the fast paced nature of the computer science and IT industries and also the diversity of skills requirements from SMEs to larger organisations.
- Recognising the value of work experience, through placements, internships and sandwich years, accreditation could be used to promote the importance of work experience to students. Students are less motivated to undertake activities and modules that are non-credit bearing.
- Recognising the heterogeneity of courses and have accreditation that was able to differentially apply to types and varying depths of courses.

6.45 As already discussed, the review has gathered evidence which supports the role of HE providers to provide the underpinning theories, principles and knowledge of Computer Sciences which are particularly valued, rather than to teach specific types of technologies (which often become out of date very quickly). The focus group discussions support a view that accreditation continues to have a role in identifying and accrediting those core skills. But it should also assess whether students are enabled through their degree programme to commit to building on those skills by continuing professional development throughout their careers, so that they can adapt and learn new technologies to reflect the fast changing skills needs of industry – developing the notion of a professionalism within the discipline.

6.46 The stakeholder survey and focus groups also indicated that accreditation can bring significant value in terms of ensuring the overall coherence of degrees and in ensuring that programmes continue to include a consideration of the legal and ethical dimension. However, the Computer Sciences and IT umbrella is heterogeneous, and 'Computer Sciences' as a label for a set of degree programmes is complex as it comprises a broad range of courses. Therefore, the evidence gathered in the survey and focus group indicates that, while accreditation should aim to assist in shaping the skills and outcomes that graduates are expected to achieve, it should avoid being too prescriptive about content.

6.47 As well as highlighting the positives, the review has also found that reports arising from accreditation visits can be useful tools for negotiating with senior management in HE providers to get increased funding for staff and facilities, such as lab spaces, to ensure accreditation requirements are met.

6.48 Focus groups also confirmed that some Computer Sciences students are undertaking qualifications additional to their degree programmes, such as CCNA from Cisco and Prince 2, where there is evidence of demand from employers. Current curricula could be aligned to enable students to undertake such qualifications. They are not recognised as part of the accreditation system but may be seen as a useful addition to a student's skills set.

6.49 Finally, discussions at the focus group indicated a desire for other types of degree to be included in the Computer Sciences accreditation framework, for example Computing and Business degree programmes which currently sit outside of the system.

The student perspective – interviews with a sample of Computer Sciences graduates

6.50 The review has also drawn on the findings of telephone interviews with 64 Computer Sciences graduates from undergraduate degree programmes in 2010-11[56]. The interviews were undertaken as part of a research project led by IFF Research on behalf of BIS[57]. It explored the experience of Computer Sciences graduates and their perspectives on what lies behind the observed employment outcomes for their discipline.

6.51 The sample of graduates was intentionally biased to help gather more qualitative information about the experiences of individuals who had experienced less positive

[56] Computer Sciences graduates from the 2010-11 cohort who had responded to the LDLHE survey

[57] Computer Science Graduate Employability: qualitative interviews with graduates, IFF, BIS Research Report 274 (2016)

employment outcomes and/or had demographic characteristics more generally associated with less positive outcomes. The study focussed in particular on:

- Those not in work 6 months after graduating
- Those not in work 3.5 years after graduating
- Those who attended an HEI with lower entry requirements

6.52 The study found that, for the graduates interviewed, less positive employment outcomes were sometimes linked to choice of HEI and a course being convenient because of its location, rather than because of the course content or the employment outcomes of former graduates. For example, it allowed them to continue to live at home with parents or reflected family or caring responsibilities that would continue while they studied. For these students, this then restricted their access to certain opportunities, such as the availability of work experience.

6.53 In particular, those interviewed recognised (albeit in hindsight) the importance and benefits of relevant (computer science) work experience to more positive employment outcomes. The sample considered work experience taken during a course to be crucial to gaining workplace and commercial understanding, and also to developing soft skills that employers value. Of those interviewed, opportunities to undertake work experience were often researched by the student, either by selecting a sandwich course or organising their own placement during their studies. A number of those interviewed who did not undertake work experience had made the active choice not to. A number failed, at the time, to recognise the importance or value of gaining work experience. Some had chosen to prioritise their studies over work experience, were keen to complete their studies before entering the labour market, or cited reasons relating to (in)convenience – such as the distance of travel involved – for not taking up work experience during their course. Those interviewed who felt that they lacked the technical and soft skills required by employers were, without exception, graduates from non sandwich year programmes.

6.54 There were mixed views among the sampled graduates about how well Computer Sciences courses prepared them for the world of work, and whether the balance between technical and general skills was correct. Most were generally expected to pick up soft skills during their course, but few did this in a structured way through team-working or presentation opportunities. Some felt that their technical skills could have been more relevant (in terms of particular coding or language development) and had become outdated in a fast paced sector. More generally, several graduates felt that their university could have done more to prepare their commercial skills or business acumen – again, work experience was a great opportunity for this but it was not always offered or taken up. However, they also highlighted the differing and unclear expectations of employers. According to a handful of graduates interviewed, employers want individuals who are a 'jack of all trades', but also have specialist skills.

6.55 Those sampled graduates that were dissatisfied with their course, or re-assessed the value of their course on graduation, found that it did not always adequately prepare them for the world of work. This was especially the case for those that had less understanding of computer science upon applying to university or had done minimal research when selecting their provider or course, or had chosen it for convenience.

6.56 Of the sample, it appeared that those who had more proactively planned their degree subject choice and location, and been more engaged in their careers from the outset of their degree, experienced better employment outcomes – there is therefore a difference in outcomes for those who might be termed as ‘planners’ and those who might be ‘drifters’. The specific careers that the sample of graduates were particularly interested in included: teaching; working in animation or computer gaming; programming; data analysis; network administration; IT or technical support; website or application development. The study found that most of those interviewed had sought out informal careers advice from lecturers, friends and family, and had avoided more formal routes such as careers events, which they saw as too generic.

6.57 The study indicated that, of the sample interviewed, the graduates employed in more ‘technical roles’ received less training compared to those in ‘customer focused’ ones. The sense was that graduates in ‘technical roles’ were more likely to have targeted their applications towards a particular type of work, and applied for roles which suited their skill set – as a consequence they put forward that they were less likely to need further skills training. The study found little evidence of employers providing formal training. Many of the graduates interviewed had sought to improve their employment chances by updating or expanding their skills base, for example by undertaking further study, formal training and online courses. This provides the review with an insight into what students may be doing between the six and 40 month census points for the destinations surveys which has such a positive impact on their employment outcomes by the second survey.

6.58 Even though the vast majority of graduates had taken a BCS accredited course, they were either unaware of course accreditation or ambivalent about its impact and value. As such, course accreditation had little or no influence on graduates when choosing their specific course or HE provider.

6.59 The study indicated that a number of related factors shaped employment outcomes for the graduates interviewed: the individual choices of the graduates themselves – whether or not to take up a work experience placement, and a lack of support in decision making and / or lack of awareness or understanding of the impact of their decisions on their employment outcomes.

6.60 Overall, there was strong evidence of positive employment outcomes at the time that the graduates were interviewed (between 3.5 and 4 years after graduation). Most graduates surveyed were in full time permanent employment which used their computer science skills at least to some extent. The research found evidence of graduates initially taking on low level and low paid roles to build up experience and skills which then enabled them to successfully apply for better paid and higher level roles. This aligns with the LDLHE statistics, which found that 5 per cent of Computer Sciences graduates from the 2010-11 cohort were unemployed 3.5 years after graduation, 13.4 per cent were in non-graduate roles and 16.8 per cent were paid less than £20,000. This is in sharp contrast to the employment outcomes for these graduates six months following graduation, when 15 per cent of these graduates were unemployed, 24.2 per cent were in non-graduate roles and 39.4 per cent were earning low salaries – see Figure 13 for how these statistics compare to all STEM graduates and all HE graduates.

Summary of qualitative evidence gathering

6.61 The evidence gathered through the stakeholder survey, focus groups, qualitative interviews with Computer Sciences graduates and wider discussions has provided further depth to the initial analysis conducted into the DLHE data. The evidence shows that Computer Sciences graduates will continue to be in demand to meet the needs of an increasingly digitally driven economy. However, while the skills gap may exist, measuring and quantifying this gap is complicated by the different needs of employers and their expectations of graduates. This often results in frustration among HE providers, their students, and recent graduates who are entering a highly competitive jobs market. Graduates are, however, engaging with their careers by upskilling, undertaking further study or building up a portfolio of work experience to help them to meet employer demands and ensure longevity of their careers. Engagement between HE and industry is already well evidenced across the HE sector, and more can be done to help graduates to gain the experience they need during their studies to experience positive employment outcomes. Accreditation appears to currently play a minor role for employers, students and some HE providers.

7 Conclusions and recommendations

7.1 The primary aim of this review was to identify the factors that might help to explain why Computer Sciences graduates appear to suffer from long-standing and consistent patterns of higher unemployment relative to their STEM peers. Where possible, it was also the review's aim to try to identify solutions that may help to improve outcomes. They are presented below together with 10 recommendations that we believe will help to address some of the identified issues.

7.2 In many areas, the performance of Computer Sciences graduates from English HEIs is outstanding, and the majority of graduates go on to fulfil important and rewarding jobs. They possess and demonstrate skills which contribute, and are vital, to the UK economy. Computer Sciences graduates are providing much of the skills and expertise that underpins the growing contribution that technology is making to all areas of UK industry, and it is important that we avoid the perception that Computer Sciences is a discipline which in some way requires 'fixing'. There are improvements in a number of areas that could and should be pursued to support the improvement of outcomes, but there remains much that is good about the discipline, and that should be preserved going forward.

7.3 The review has identified a number of factors that contribute to the outcomes observed in the data. It is important to state that the evidence has indicated a mixed, and at times contradictory, picture of graduate employment outcomes and the potential contributing factors. Computer Sciences degree programmes span a broad curriculum, and are taught at a wide range of providers and, like the industries that they serve, the discipline is not homogenous. A wide range of representatives from professional bodies, HE providers and employers have provided evidence and data to the review, which points to a multi-faceted HE sector – with mixed graduate employment outcomes – and a diverse industrial landscape – with different requirements of its graduate employees. The evidence suggests a complex picture of the interrelationship between the supply of graduates (and their individual characteristics) from HE, the varying nature of the demand for skills from employers, and the role played by the professional bodies in helping to bridge two sets of interests. The story is not straightforward, and there is no single headline figure or data set that comprehensively conveys the graduate employment situation.

7.4 However, the review has identified a number of themes and issues which we believe can play a role in improving graduate outcomes. These themes have formed the basis for the conclusions and recommendations that emerge from our findings and are presented under the following four headings:

- Data
- Supply
- Demand
- Accreditation

7.5 The recommendations also include guidance for HE providers and employers in enabling Computer Sciences graduates to be in the best position they can to meet the evolving needs of employers and the economy. The recommendations and guidance are relevant to all HE providers and particularly for those where the data seems to suggest particularly high unemployment rates six months after graduation. Where possible, we have provided specific examples that demonstrate a particular conclusion. These examples have arisen during the evidence gathering phases of the review. The recently published CPHC report *Computing Graduate Employability: Sharing Practice*[58] also contains case studies from across the full range of UK HE providers. We also reference the CPHC report throughout the conclusions, where examples help to illustrate initiatives already under way across higher education.

Data

7.6 The destinations data on graduate outcomes available from HESA through the DLHE and LDLHE surveys has formed a core component of our investigations and has highlighted some interesting issues. At the broadest level, it shows that Computer Sciences graduates suffer from poorer employment outcomes relative to other STEM disciplines and when compared to graduates from all disciplines at higher education level. However, it also shows that these outcomes improve significantly over time – the unemployment rate for Computer Sciences students who qualified in 2010-11 drops from 15 per cent six months after graduation, to 5 per cent 40 months (or 3.5 years) after graduating. While this overall unemployment figure is still slightly higher than the figures for STEM overall and for all subjects at higher education level, the statistics for the other indicators that we have used to measure employment outcomes – the proportion of graduates in non-graduate roles and the proportion of graduates earning low salaries – present a favourable picture for Computer Sciences graduates. These proportions are comparable to all other STEM disciplines and significantly lower than the same statistics for graduates from all subjects at higher education level.

7.7 Beneath these overall figures, there are variations between and within groups of HEIs, when these HEIs are classified according to the average UCAS tariff of their young entrants. Further aggregation of the data shows that employment outcomes for Computer Sciences graduates vary according to equality groups such as a student's age, ethnicity and background. However, while these outcomes are more exaggerated for some student groups, they largely follow the trends we see for the same groups of students across the whole of higher education. This makes it difficult to reliably say that these issues are specific to Computer Sciences graduates without further, more detailed research. When we look at the outcomes of graduates according to the type of course they study, however, we see particularly impressive outcomes for all graduates from sandwich courses and those graduating from integrated Masters degree programmes.

7.8 The destinations data has proved a useful source of information on demand for Computer Sciences graduates – this will be further enhanced by the availability of linked educational and employment record datasets that the Government expects to make available later this year. Additional data on what graduates do when they leave HE is available from a range of both public and private organisations in the form of surveys and reports. Evidence

58 http://cphc.ac.uk/publications/reports/

gathered from these sources has in many cases helped to support the data we have been able to access through HESA, with surveys undertaken by the UKCES on what demand from employers currently looks like, and studies like the Working Futures report referred to in Chapter 3 – which help to indicate what future demand might look like – having been particularly informative. We would highlight the need for such surveys to continue in the future, particularly in view of the decision to close the UKCES within the next few years. The *Tech Nation 2016* report[59] has also provided valuable insights, highlighting the increasingly important role of clusters of regional activity. However, gaining access to available data, analysing and then presenting it for the benefit of a variety of audiences and purposes is not straightforward. More needs to be done to better integrate these data sources and to ensure that they are opened up to be scrutinised by all.

7.9 Understanding the evidence around the demand for skills has proven particularly challenging. The sources currently available to assess and predict demand lack sufficient levels of detail on the specific skills that employers are looking for, and where in economic and geographic terms these skills are required. This may indicate that either the data is not being gathered and interpreted adequately, or that more needs to be done to work with employers to better articulate, capture and present their views. We suggest further ways that this specific conclusion can be addressed under **Recommendations 6, 7 and 8**.

7.10 The recommendations set out below therefore address how we might better access, use and exploit the data[60].

Improvements to existing data and requirements for new data

i. **Improvements to existing data –** a number of improvements to existing data sets would be welcome, in particular:
   - A common language around work experience should be agreed to avoid ambiguity around terms such as internship, placement, industrial project.
   - The Standard Industrial Classification (SIC) codes used are not fit for purpose and should be revised to reflect modern and emerging areas of the digital economy. This aligns with findings in the 2016 Tech Nation report.

ii. **Supplementary data –** alongside improvements to existing data, supplementary data should be collected in the following areas:
   - Work experience:
   – HESA's existing work to review graduate destinations and outcomes data and wider work on Data Futures should include a commitment to collecting the different types of work experience that students engage in beyond the traditional one year sandwich placement which is currently captured in data collection. This should include experience of varying lengths and at various locations, whether paid or unpaid, informal or formal.

59 www.techcityuk.com/technation/

60 The review acknowledges HESA's current review of destinations and outcomes data, which is due to report in Spring/Summer 2016, and the wider Data Futures Programme which aims to better consolidate data collection while reducing burden and responding to the multiple needs of a wide range of data users.

- Industry demand:

– HESA's existing work to review graduate destinations and outcomes data and wider work on Data Futures should consider how current data collection can provide more information on the skills that graduates are using in their roles. This would go beyond the current statistics available on job type collected in the DLHE and published according to the Standard Occupational Classification 2010 and the Standard Industrial Classification 2007.

– The AGR and AGCAS, representing careers services within HE providers, and CPHC, representing Computer Science departments within HE providers, should work together to improve our understanding of the skills market in computing, and specifically on the following:

  - Devise routes to collaborate with local and national recruitment agencies to provide an accurate and live overview of the skills needs of employers across industry types and region.

  - Work with organisations that conduct their own formal and informal surveys of employers and members to assess skills needs. Examples of these organisations, include the British Chambers of Commerce (BCC), UKCES (or its successor), the CBI, the BCS, the IET, the EEF and the Tech Partnership. This information should provide a more comprehensive assessment of employer demand for skills to inform careers advice to both prospective and current Computer Sciences graduates but also to help keep Computer Sciences departments aware of particular trends in skills needs and/or location of skills needs.

  - Consider how more use could be made of real time data to inform the alignment of supply of and demand for skills. Countries such as Australia are using data gathered by recruitment companies like Adzuna[61] to inform their understanding of current employment markets. This information supplies the Australian government with up to date, real time information about job vacancies and placements. In the UK, SkillsPlanner[62] will be a live, user-friendly, open data platform that will allow employers, skills providers and other stakeholders to share past, present and future skills data. The first stage of the initiative will focus on addressing skills gaps in the construction industry in London.

  - Consider more broadly how best to exploit the information about the skills of Computer Sciences graduates available through social media and online development platforms such as GitHub[63].

61 https://www.adzuna.co.uk/?gclid=CLuPseLot8oCFeTnwgodkW4IJQ

62 www.skillsplanner.net/

63 https://github.com/

- Student characteristics:
  - Statistics collected in the DLHE survey should consider how it can help to provide more information on the barriers that students may face in the years immediately following graduation. While these issues are not unique to Computer Sciences, data collected may help to provide a clearer picture of the barriers faced by particular groups of Computer Sciences graduates when seeking permanent employment, for example women and BME graduates. Data should also be collected from employers on the training offered to graduates. This should include any information on informal and formal training to help build a picture of the changing demands of industry but also to help to better track a graduate's route through their career.

Making data more accessible

- Data (and metadata) that is not currently available under open data licences should be made available so that it is accessible to as wide an audience as possible. Metadata should be available to enable the user to assess the appropriateness and validity of different data sets. Existing data on graduate outcomes, on supply of graduates from higher education and demand for skilled graduates from industry, is currently dispersed across a wide range of sources with varying levels of access. Improving access to data increases the opportunities to engage with a broader audience that can help to ensure that the skills needs of industry are met and continue to be met in the future. Both existing, and the supplementary data outlined above, should then enable an 'active' feed, or 'dashboard'[64], of information that provides a real-time picture of supply and demand in relation to Computer Sciences. This information would facilitate horizon scanning for future skills needs which is outlined in **Recommendation** 8.

Recommendation 1 – Improving the data

Data on the supply of and demand for Computer Sciences graduates should be timely/up to date, accessible and comprehensive. CPHC, AGR and AGCAS, and Tech Partnership should devise a programme of work to improve the quality, richness and granularity, availability and accessibility of data. This should start by working with HESA to inform their Data Futures review and with Government on the future publication of linked educational and employment record datasets. This will help HE providers, employers, students, graduates and policy makers to better understand the graduate employment landscape and how this meets both the requirements of industry and an increasingly technology-driven economy now and in the future.

64 Dashboards should look to build on existing practice, such as the data.gov.uk website that brings varying Government and partner organisations' data sets together in one searchable format and the performance dashboard at https://www.gov.uk/performance

Supply

7.11 Computer Sciences as an academic discipline is one of the largest of the STEM disciplines in terms of student numbers, and is taught across the majority of England's 130 publicly-funded HEIs. The data demonstrates that Computer Sciences attracts a broad range of students who study at a large variety of HEIs. It also tells us that there are variations in graduate employment outcomes across a number of different factors:

- Type of HEI (as measured by average UCAS tariff scores of its young students)
- Gender
- Ethnicity
- Age
- Low Participation Neighbourhood
- Disability
- Degree course structure
- Type of course

7.12 The data presented and summarised in this report highlights the complexities around the employment picture for Computer Sciences graduates. It demonstrates that particular groups or sub-sets of groups of students appear to experience less positive employment outcomes compared to other groups. The review is particularly concerned about the findings that female Computer Sciences graduates and BME Computer Sciences graduates experience less favourable employment outcomes. When compared with the data available on outcomes of graduates from other STEM disciplines and graduates from across all disciplines at higher education level, however, the data also suggests that these patterns and trends are largely consistent with those found among STEM and all graduates from higher education, but they are more pronounced in Computer Sciences for some groups.

7.13 There are, however, two areas of interest that are highlighted by the data: degree course structure and type of study. A clear trend is presented in the data, in that those graduates who studied degree courses that featured sandwich year placements tend to enjoy significantly better employment outcomes compared to graduates who studied courses without a sandwich placement. The findings of the data in relation to type of study are also of note, with a pattern suggesting that graduates who studied Computer Sciences as part of an integrated Masters course went on to achieve markedly better employment outcomes relative to those that studied a traditional three-year Computer Sciences course – regardless of whether this included a sandwich year or not.

7.14 A number of clear themes have emerged from the evidence gathered through the online survey and focus group that help to explain some of the reasons why these particular types of course lead to such favourable employment outcomes. These relate to the skills, knowledge and experience that graduates learn and are exposed to during their time in higher education and include:

- The importance of students having either formal or informal **experience of the world of work**

- The value that many employers appear to place on Computer Sciences graduates having a solid base of **foundational knowledge** in Computer Sciences and being able to **apply and adapt** this to real world contexts
- The continuing significance of graduates being able to build and develop '**soft**' or **'work readiness' skills** which help them to apply their specific skills and knowledge in the business and professional world
- The continued engagement that Computer Sciences graduates require with **career planning and services** to build their **knowledge of the career opportunities** that their degree courses could help them access

Work experience

7.15 Although it is a recurring point in discussion around graduate employment outcomes, it is important to re-emphasise that work experience matters: to students, to employers, and to HE providers. The review has gathered much evidence that suggests that almost any experience of the world of work helps to equip graduates with the skills they need to be able to secure a job and, once in a job, to apply, adapt and update their knowledge to the workplace.

7.16 As set out previously, destinations data points to a clear, positive link between degree programmes that feature one-year sandwich placements and better graduate employment outcomes. However, it can only tell us part of the story – as we have already highlighted, it does not collect data on less formal types of work experience and we have therefore made a specific recommendation to ensure that this is addressed in the future. As well as using improved data to understand the benefits of different types of work experience, we also need to understand how those benefits could be transferred to students who might struggle to access work experience and placements.

7.17 The qualitative evidence that the review has gathered has added more detail. A clear and consistent theme emerging from the review's online stakeholder survey and targeted focus groups, together with the telephone research carried out with a small sample of Computer Sciences graduates, is that almost any type of work experience is viewed, both by employers and students themselves, as beneficial to graduate employment outcomes. Examples of informal work experience opportunities might include internships, voluntary work and holiday jobs. Throughout the qualitative evidence-gathering, employers in particular consistently highlighted that they are looking for graduates who have demonstrable experience of the workplace. This includes interacting with colleagues, working within and across teams and being able to think about how their skills and knowledge can be practically applied in a professional work context.

7.18 Interestingly, the qualitative evidence has also pointed to graduates often seeming to lack awareness of the importance of work experience in terms of its potential contribution to their ability to secure positive employment outcomes. Part of what the review would like to see, therefore, is more effective engagement by HE providers with its students and graduates to reinforce the important role that work experience plays. It is evident that students and graduates bear a large proportion of the responsibility for engaging with and thinking about their careers and the already excellent careers advice that many HE providers facilitate. Students and graduates need to do more to take responsibility for their future careers and employment outcomes.

7.19 It is also important that, where there is scope for expansion of provision and take-up of work experience opportunities, we need to ensure the quality of such opportunities. Stakeholders have been clear that, while expanding the range of work experience opportunities is an important part of attempting to improve graduate outcomes, that work experience should be sufficiently challenging to enable them to develop their skillsets. Many HE providers already run innovative programmes[65] to help provide students with access to different types of opportunities. Further examples are included throughout the CPHC Employability report. In Scotland, partnership working between Edinburgh Napier University, e-Skills UK and ScotlandIS has developed an innovative, national level scheme – ePlacement Scotland – to increase employer engagement to expand and enhance high quality work placement opportunities, in particular developing a strong reach into and across Scottish SMEs. Initiatives such as this provide helpful models that could be considered in any future work to expand the array and quality of work experience opportunities for graduates.

7.20 Consideration also needs to be given to how the skills, knowledge and exposure to the world of work that placements provide can be embedded more systematically in degree courses themselves. Work experience opportunities, either formal or informal, are unlikely to be either feasible or desirable for every student. Therefore, the review recommends that more needs to be done to consider the key benefits that work experience provides students. HE providers should consider how these benefits can more routinely form a core part of existing degree courses. Again, the CPHC report *Computing Graduate Employability: Sharing Practice*[66] demonstrates this through case studies from across the higher education sector in the UK.

7.21 University Industry Advisory Boards (IABs)[67] are university-convened groups of employers, industrialists and academics that come together to develop and enhance degree programmes. They aim to promote closer academic/industry research collaborations and examine new educational ideas. IABs have a potentially important facilitating role to play in relation to work experience, developing links and exploring opportunities for collaboration. However, the review has heard varied experiences of the impact and usefulness of IABs, with some stakeholders voicing concerns that they can be cosmetic and lack real and meaningful engagement between HE and industry. Computer Sciences departments and employers should, therefore, look to ensure that IABs do provide a meaningful framework for this interaction between business and academics and bring expertise in addressing how to expand work experience opportunities. The assessment of the impact of research in higher education through the REF already demonstrates the range and significance of contact between HE and industry. Using IABs, these types of interactions and relationships should be built on and expanded, to bring added value for Computer Sciences students.

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65 www.cs.ucl.ac.uk/careers/ and www.ucl.ac.uk/advances/advances-programmes/summer-internships

66 http://cphc.ac.uk/publications/reports/

67 An example of a typical IAB can be found here: www.nottingham.ac.uk/computerscience/workingwithindustry/industrial-advisory-board/industrial-advisory-board.aspx

7.22 During the evidence gathering, we have encountered a number of examples of ways in which work experience opportunities could be broadened out, and through which students, graduates and lecturers can be exposed more regularly and effectively to industry and employers. Examples of the types of interaction that the review has encountered have included:

- Industry-led project work and competition
- Increased levels of industry engagement with HE to help design courses and curricula
- Industry-led teaching and lectures
- Using industry contacts to provide a 'critical friend' role in assessments of students' academic work
- Academic secondments into industry allowing academics and lecturers to develop experience that can be passed on to students

Recommendation 2 – Extending and promoting work experience

All Computer Sciences students should have opportunities to benefit from the skills and experience that are gained through formal sandwich year placements. This might be through increased provision of different types of work placement or finding ways to transfer the benefits of work placements directly to degree programmes. HE providers and employers should be creative and ambitious in developing mechanisms and routes for students to gain work experience, including summer internships and shorter placements. University Industry Advisory Boards should facilitate genuine engagement between HE and industry to ensure that these opportunities are relevant and provide real-world examples.

NCUB, CPHC and NUS should work together to investigate the barriers (perceived or actual) that different groups of Computer Sciences students face in accessing and undertaking work experience that is unpaid or voluntary.

Improving graduates' foundational knowledge and their ability to adapt

7.23 The fast-paced nature of digital and computer science technologies, and the challenges this poses to graduates, HE and employers, has been a consistent theme throughout the review. Evidence gathered from employers through the online stakeholder survey, focus groups and other reviews and reports have pointed in different directions. Some employers have said they want graduates who are skilled in the most recent and up to date programming languages and software engineering methods in response to the fast-paced development of digital technologies. But many have also said that they require graduates with a sound grasp of the fundamental, and unchanging, core principles which underpin Computer Sciences as a discipline: It is this grounding, many employers argue, that allows graduates to be flexible in the context of a fast-changing technological landscape and to adapt as industries, systems and thinking evolves. The review was presented with the example of Symbian[68], a former operating system that was in use in the large majority of mobile phones for a period during the late 2000s and which disappeared from the technology market in a short space of time when a new operating system appeared. This represents a specific example of the fast moving nature of technology and the risks to HEIs – and students and graduates – if they are expected to align their curricula with the latest, or 'in vogue', technologies.

7.24 Based on the available evidence, the review concludes that graduates need to be equipped with the skills and knowledge to meet both of these challenges. HE providers must ensure that their courses are responsive to the fast pace of change in technology, imparting an appropriate level of knowledge to students about the technologies and systems which are at the forefront of current thinking. However, degree courses also need to provide students with knowledge and understanding of the core foundational principles of the discipline and, in particular, the ability to take that knowledge and apply it to modern, dynamic industries. Such a challenge requires not only HE providers but also employers to provide the appropriate training and continuing professional development to support graduates as they progress through their career.

7.25 Cyber security is one area which brings these issues to life; where graduates must apply core principles to a fast-changing setting in which flexibility, creativity and adaptability are key. A range of bodies and organisations are working in partnership to address the challenges of equipping graduates with the right skills. Working with UK Government, the National Cyber Security Programme brings together a group of delivery partners to increase the UK's educational capability in all fields of cyber security. This includes BIS, EPSRC, GCHQ, CPNI and OCSIA, who have developed training programmes which will be assessed against the nominated area(s) of the Institute of Information Security Professionals (IISP) Information Security Skills Framework and accredited by the GCHQ certified training (GCT) scheme. There will likely be further areas of national importance that will require Computer Sciences departments to work in collaboration with other delivery partners to deliver courses that meet a very particular need and to an agreed accredited framework.

7.26 It is important that the autonomy of HE providers to provide degree courses that reflect their own individual specialisms and strengths is maintained. Where relevant, this should continue to be developed in line with Quality Assurance Agency for Higher Education (QAA) subject benchmark statements. Subject benchmark statements describe the nature of study and the academic standards expected of graduates in specific subject areas, and in respect of particular qualifications. They provide a picture of what graduates in a particular subject might reasonably be expected to know, do and understand at the end of their programme of study. Recognising the diversity of Computer Sciences-related courses, the subject benchmarks refer to the Association of Computing Machinery (ACM)[69] curricula documents for the required body of knowledge.

68 www.pcworld.com/article/2042071/the-end-of-symbian-nokia-ships-last-handset-with-the-mobile-os.html

69 https://www.acm.org/education/curricula-recommendations

7.27 Recognising this autonomy, QAA subject benchmarks and the ACM body of knowledge, we have been conscious throughout the review to avoid making recommendations that prescribe what HE providers should or should not include in their undergraduate degree programmes. Rather we have been keen to highlight the importance of undergraduate courses in Computer Sciences, recognising the fast pace of change in technology and equipping students with the skills to learn and upskill throughout their degree programme, but also during their professional careers. We therefore suggest that HE providers consider how they might develop a number of short, focused courses that provide opportunities for existing students and graduates to 'top up' their existing skills and which fulfil a requirement for continuous professional development. The Agile Accelerator at Aston University and Business Innovation for Digital Technologies at the University of York are two examples from the CPHC report that highlight how HE providers are offering extra-curricular modules to their students to improve employability.

Recommendation 3 – Ensuring graduates' foundational knowledge and their ability to adapt

Course provision should recognise the fast pace of change in technology and seek to equip students with the ability to learn and upskill both throughout their programme, but also during their professional careers. However, HE providers, whether accredited or not, must also ensure that degree programmes continue to provide students with the core foundational knowledge and principles of Computer Sciences. This core should reference the Association of Computing Machinery (ACM)[70] curricula documents for the required body of knowledge.

Improving graduates' softer and work readiness skills

7.28 The review has found consistent evidence of employers articulating dissatisfaction with graduates' soft or work readiness skills. While these skills are generic and not specific to Computer Sciences, the skills mentioned include: the ability to deliver presentations, project management, commercial awareness (including an understanding of the business environment and for example profit motives), ability to work with colleagues in and across teams, and report writing. We recognise that the HE sector has made significant strides in recent years to try to address this issue across the full range of disciplines, but more needs to be done to ensure that Computer Sciences students have the opportunities to develop these skills during their degree programme. HE providers should also be aware of the findings of the review and the CPHC report, which highlight the differing motivations of students – for example, that some students may not recognise the value of a particular module or activity if it is non-credit bearing. The review also notes that employers should recognise the role they should expect to play in training graduates 'on the job'.

70 https://www.acm.org/education/curricula-recommendations

Recommendation 4 – Improving graduates' softer and work readiness skills

HE providers and employers should consider how new models of provision, such as degree apprenticeships, may provide opportunities for students to develop work readiness skills alongside their academic studies. Employers should work with HE providers to support them in incorporating these opportunities into degree programmes. Employers should also recognise their role in providing training to graduates to enable them to develop professionally and to adapt their skills to the specific needs of a particular employer or industry.

Tech Partnership, BCS and IET should work with employers and HE providers to accredit modules that provide students with both technical and soft skills and to ensure they are valued by students.

Careers advice and visibility of graduate opportunities

7.29 Careers services within HE providers should work closely with Computer Sciences departments to make careers advice more visible and relevant to graduates, and should explore ways in which this could be incorporated more routinely into existing degree programmes. We have gathered evidence that, outside of the large and well-known technology companies, the potential computer-related careers paths on offer to graduates can often be unclear and that graduate outcomes can be impacted through a lack of knowledge about the industries in which they could make effective use of their skills and knowledge. We have also heard anecdotal evidence to suggest that, in some cases, where graduates are aware of opportunities in lower profile sectors and industries that some turn down roles that do not meet their expectations.

7.30 Additionally, the review has heard evidence to suggest that many Computer Sciences graduates are often in possession of the soft skills that they require to operate effectively in the jobs market, but that a number of them struggle to articulate their skillset to employers. Computer Sciences departments and careers services should work collaboratively to ensure that students take full advantage of the support available or co-design tailored support for students to address these issues, ideally within the curriculum or in co-curricular ways.

7.31 Although consideration of pre-HE education has not been within the scope of our investigations, we have heard anecdotal evidence to suggest that some of the issues affecting employability have their origins earlier in the educational pipeline. Through outreach networks providers should offer up to date and high quality information, provide role models and seek new and different ways to enthuse and engage young people about the full range of possibilities in IT and computing. Such efforts are aimed at sustaining the diversity of applicants to Computer Sciences degrees. This should proactively address, for example, the low numbers of women who choose to study Computer Sciences at university – something which this review is particularly concerned about, but which is outside of its scope. The review acknowledges the impact of initiatives such as 'Computing at School'[71],

71 www.computingatschool.org.uk/

and changes to how Computer Sciences are to be taught in primary and secondary schools. However, any change lower down in the system will take time to reach fruition as these pupils progress through the education system.

Recommendation 5 – Careers advice and visibility of graduate opportunities

The AGR and AGCAS should work with CPHC and Tech Partnership to develop a targeted campaign to provide Computer Sciences students with more specific detail on the types of roles and industries that require their skillsets. This should seek to identify role models from alumni and local industry contacts. This should be disseminated and led locally by careers services who should provide support to students in articulating their skills to potential employers. The BCS and IET should work with AGR and AGCAS to develop a model for accrediting careers advice provision within Computer Sciences programmes.

Demand

7.32 The destinations data has provided the review with a substantial amount of information on graduate employment outcomes from the perspective of the supply side: the destinations of graduates from Computer Sciences degrees, the numbers of students entering degrees, and how graduate outcomes differ according to student and course characteristics. However, data and evidence on the types of industries and job roles that Computer Sciences graduates are going into; the skills and knowledge that graduates have gained during their degrees; their relationship with graduate effectiveness in employment; and the wide ranging and nuanced requirements that employers have for computer science skills, has been more difficult to source, access and interpret.

7.33 The review's recommendations related to improving data have already highlighted the need for better granularity, consistency and reliability of demand-side data. Some of the issues with this mismatch between supply and demand-side data highlighted throughout the review, include:

- Matching data on supply of graduates and their destinations by Standard Industrial Classification with data on employer demand for specific skills
- Understanding how demand for Computer Sciences graduates differs across the UK
- Agreeing on whether employers require graduates from Computer Sciences for tech-related jobs

7.34 The industries that seek to employ Computer Sciences graduates are not homogenous, and their skills and knowledge requirements understandably differ. Destinations data, backed up by existing literature from UKCES and other organisations, highlights that demand for Computer Sciences graduates is spread across a range of industries, and this diversity provides challenges to developing a clear taxonomy for the requirements of employers.

7.35 Some of the qualitative evidence that the review has gathered has, for example, suggested that companies focussed on IT development – for example software engineering companies – require graduates with ‘hard’ technical skills, whereas those which could be categorised as consultancy or service-based businesses are likely to require graduates with a solid understanding of the most recent and up to date technologies and who have the ‘soft’ customer-facing and commercial skills to enable them to operate in heavily client-focused contexts. Some industries are ‘faster changing’ than others, and therefore the skills they require will become more quickly outdated than others. In addition, the amount an employer is willing to commit to training or shaping recent graduates depends on their available resources and time.

7.36 There is evidence of growing demand for skills in specific areas of Computer Sciences, including cloud computing, data analytics, cyber security, FinTech and HealthTech, which are all regularly referenced as significant areas of growth and that will have major roles to play in future economic development and productivity. Some specific and highly technical areas linked to Computer Sciences have already been targeted by the Government and other partners. For example, GCHQ recently announced its intention to recruit large numbers of new employees. Expansion in areas such as this will require specific types of Computer Scientists. Understanding where this type of demand is likely to occur is challenging.

7.37 The following recommendations related to demand are therefore focussed on different types of employers.

Developing a clearer view of the requirements of start-up technology companies

7.38 More information is needed on the nature of the demand from start-ups for Computer Sciences graduates. The Tech Nation report cites the ‘*Power of Clusters and Networks*’ as key players in supporting growth across UK cities. These clusters, which include both small and larger corporations (but have significant numbers of start-ups), are growing at a faster rate than their local economies. According to the report, there are 58,000 digital tech businesses in the UK with the majority (17 per cent) involved in app and software development, followed by data management and analytics (12 per cent) with hardware, devices and open source hardware (11.5 per cent) the third largest digital tech sector. And 55 per cent of digital tech businesses cited access to university talent as the third most important benefit of the cluster (behind access to local networks and access to commercial property).

7.39 The report also signals some worrying trends in the mismatch between the supply of graduates and the demand from clusters of tech businesses. The report states that 20 per cent of digital tech businesses say that EU countries are an important source of talent, with one in three digital tech businesses sourcing talent from local universities. Interestingly, digital tech businesses state that self-taught programming and in-house training are the most important sources for skills development, with 15.4 per cent saying UK universities are an important source. This adds weight to the argument for closer links with all sizes and types of businesses to develop a clear picture of how growth in demand in digital technology is likely to develop, what the specific demand from digital technology start-ups looks like and what role HE providers could play in both meeting this demand, but also taking advantage of local clusters of activity for its students and graduates.

7.40 The Tech Nation report provides a range of case studies on clusters (which are dominated by start-ups) across the UK. These include the Malvern Cyber Security Cluster and the Centre for Digital Innovation in Hull. The review has also heard evidence of start-up activity such as Seedcamp[72], Bethnal Green Ventures[73] and ventures supported by the Open Data Institute[74], for example Amiqus Resolution or Brightbook.

7.41 Building on a number of recommendations included in Tech Nation 2016 and NESTA, we make the following specific recommendation for start-ups.

Recommendation 6 – Developing a clearer view of the requirements of start-up technology companies

Start-up companies should be recognised as a distinct element of the employer landscape. The skills needs of start-ups should be specifically identified, and the role that start-ups can play in providing work experience opportunities for students and inputting to Computer Sciences degree courses should be fully explored.

Tech City UK, the Open Data Institute, the Tech Partnership and NESTA should work together to act as a voice for start-up companies to enable them to interact effectively with HE providers, their students and graduates. This should reflect activity at the local, cluster level and input to enhanced data collection and analysis, outlined in Recommendation 1, to better understand the demands of start-ups.

Developing a better understanding of, and supporting, SME requirements

7.42 The review's evidence points to clear demand for Computer Sciences graduates from SMEs and this is clearly demonstrated in the Tech Nation report. The review has also heard that SMEs derive considerable benefits from the ability to host students for periods of work experience. However, we have also heard that in many cases SMEs have insufficient time and resources available to offer quality opportunities to students. The review has heard about a range of specific models for improving the extent to which SMEs can access and improve their ability to offer work experience opportunities. Some of these are provided below:

- Financial incentives that remove the risks for SMEs: RSC EnterprisePlus scheme wholly funds the first year of an SME placement, part-funds the second year and then supports the SME to take on students for a third placement year with no additional funding.
- Practical support for SMEs: Graduate Advantage in the West Midlands has been operating for 12 years and has placed 4,000 students into placements of 12 months or less. SMEs involved in the scheme value a single point of access to connect with students from a range of universities (a consortium) and free recruitment support to write an advert, advertise it and create a shortlist.

72 http://seedcamp.com/
73 http://bethnalgreenventures.com/
74 http://theodi.org/current-start-ups

- A consortium approach: two or three organisations host placement students for part of their year in industry. Could be done working through science parks where businesses are co-located.
- Industry relevant projects where the student remains working within the university facilities. Low-risk option, and allows SMEs to benefit from HE facilities and expertise.

Recommendation 7 – Developing a better understanding of, and supporting, SME requirements

Working through Tech Partnership and with Tech City UK, SMEs should be supported to ensure that their requirements for Computer Sciences graduate skills are captured and adequately reflected. In particular, further work is needed to support SMEs in providing work placements to Computer Sciences graduates.

Horizon scanning for future demand for skills

7.43 The recommendations presented here have outlined the need for better data, better engagement between HE and industry, and better understanding and recognition of the differences in the skills needs of employers. The review has demonstrated that graduates need to be equipped with core foundational skills but have an ability to adapt their skills to an ever changing technology-driven employment landscape. There are a number of highly specialised Computer Sciences-related roles across industry that are likely to emerge over the next 20 years that will be of significant economic importance to the UK, and the demand for these roles and the associated future skills requirements of graduates needs to be better understood. These areas are also important for sustaining the future academic research base of Computer Sciences. In particular, skills requirements related to data analytics, machine learning, artificial intelligence, robotics, cyber security, cloud computing and open data roles and industries. There is therefore a need to try to keep ahead of the trends to better anticipate and respond to future skills needs. This review also echoes existing calls from NESTA and UUK to develop a cross-cutting data analytics taskforce '*to identify good practices for education and skills provision, and spur collaboration across industry*'[75].

Recommendation 8 – Horizon scanning for future demand for skills

HE providers, employers, accrediting and professional bodies should work together to horizon-scan for future skills requirements of Computer Sciences graduates. The CPHC, HEFCE, Tech Partnership, NESTA, BCS and the IET should work with, and build on, existing fora to identify future skills needs. The Group should use enhanced data outlined in Recommendation 1 and work together to develop a collaborative model with a clear remit and reporting line. The Group should deliver an annual report on the skills needs of Computer Sciences graduates, delivered through an annual summit/ conference on Future Skills and with wider dissemination through local careers services.

75 www.nesta.org.uk/sites/default/files/analytic_britain.pdf

Accreditation

7.44 The review has heard strong evidence that the purpose of current systems of academic accreditation of Computer Sciences undergraduate degree courses is not well understood by students or employers. However, the review has also heard that some HE providers, and in particular senior management within HE providers, place value and importance on gaining accreditation. The review has therefore highlighted a number of areas where accreditation may play a more proactive role.

7.45 In particular, accreditation needs to be strengthened to address issues around:

i. **Agility –** the IT and technology sectors are subject to regular and rapid change. Accreditation, which aims to act as a quality stamp for degree courses, needs to be able to recognise and reflect these developments so that they can be reflected in up to date curricula for Computer Sciences, while ensuring that programmes retain a basis in the fundamental principles of computer science.

ii. **Differentiation –** the richness and diversity of Computer Sciences degrees continues to be a strength within the UK's higher education system. Accreditation systems need to be able to recognise this diversity and provide different levels and types of accreditation that can help to signpost to students and employers the types of skills and knowledge that a course will equip an individual with.

iii. **Content –** accreditation must, first and foremost provide a quality stamp for degree courses and validate that course content meets standards beyond those already served by both internal and external quality assurance processes, such as QAA subject benchmarks. Existing systems of accreditation need to change to reduce the focus on assessing process and documentation and to increase focus on the outcomes of courses, including whether courses are providing high quality, up to date and relevant material that produce graduates who are able to enter a competitive employment market. This should be underpinned by a sufficient fundamental understanding to allow graduates to embrace future technologies.

iv. **Relevance –** it is widely accepted that employers and students understand little of the current accreditation systems and even less about the benefits that a robust accreditation system could bring, including the value of professional registration. A revised accreditation system needs to ensure that the themes and issues identified in the context of this review are addressed and that graduate employment outcomes are considered. In particular, a revised accreditation system should build into its assessment framework:

   a. Work experience (of varying types and duration)

   b. Careers advice and support to both students and graduates

   c. The importance of consolidating core foundational knowledge

   d. The opportunities for students to develop soft skills within their degree programme

Recommendation 9 – Academic accreditation of degree courses

BCS, IET and Tech Partnership should ensure that existing systems of degree course accreditation are flexible, agile, and enable HE providers to respond to changing demand and emerging technological trends and developments. Accreditation of courses should be focussed on outputs. Accrediting bodies should work to increase awareness and value of accreditation so that it is valued by HE providers, students and employers, and consider how their role can provide a forum for engagement between HE and employers.

Industry engagement with accreditation

7.46 Working to improve the employment outcomes of Computer Sciences graduates is not the sole responsibility of a particular organisation or sector. The review recognises that industry also has a critical role to play in developing degree courses, in accrediting those courses and in helping to provide students with relevant work experiences. We therefore think it is important to highlight this in a specific recommendation to industry. The conclusions arising from this review point to several areas where Computer Sciences departments in HE providers and employers need to work more effectively and efficiently together for mutual benefit and for the benefit of graduates. In the course of the review, it has also become clear that current accreditation systems already see HE working in collaboration with representatives of industry to accredit degree courses. However, it is unclear as to the extent to which this collaboration is working effectively and the extent to which employers represent the true picture of the employment market – from start-ups to multinationals, and public and private sector.

Recommendation 10 – Engaging industry in accreditation

Employers, through employer groups, such as Tech Partnership, should engage more consistently with HE providers and BCS & IET to ensure accreditation is effective and reflects current industry demand.

8 Areas for future research/additional evidence gathering

The review has gathered a large amount of evidence about the factors that affect Computer Sciences graduate employment outcomes. However, there are a number of additional areas of research that would help to build a clearer picture of Computer Sciences graduate outcomes. We list some areas of research below with the intention that they may inform future policy and research agendas:

a. Student characteristics:
   i. What are the challenges facing female Computer Sciences graduates and why are more of them entering low paid roles than their male counterparts?
   ii. How can we encourage more women to apply for Computer Sciences courses to increase low participation rates?
   iii. What are the challenges facing BME Computer Sciences graduates and why are they suffering from higher unemployment rates than other Computer Sciences graduates?

b. The international dimension:
   i. What are the current patterns of the flows of Home and Overseas graduates who take up employment abroad?
   ii. Are graduates from the UK meeting the skills demands of overseas employers? Are our graduates still competitive in an international market?
   iii. Are we losing students to overseas HE providers?
   iv. To what extent are IT professionals from abroad taking on roles that may have otherwise been taken up by UK-domiciled Computer Sciences graduates and what is the impact of this (bearing in mind planned reforms to the Tier 2 (skilled worker) visa for non-EEA nationals)?[76]

c. The education pipeline:
   i. How are changes at primary and secondary education level going to impact higher education?
   ii. What are the trends in employment among postgraduate taught and research graduates?
   iii. What role can Computer Sciences-related conversion courses play in meeting employer demand?
   iv. What are the reasons that might help to explain why relatively few Computer Sciences graduates go on to postgraduate education?

d. Should accreditation go further and enable a 'licence to practice' for Computer Sciences graduates in some areas of the subject?

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[76] This expands the findings of the Migration Advisory Committee into Tier 2 Migration https://www.gov.uk/government/publications/migration-advisory-committee-mac-review-tier-2-migration

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Annex A – Glossary of terms

AGCAS	Association of Graduate Careers Advisory Services
AGR	Association of Graduate Recruiters
BCS	British Computer Society, The Chartered Institute for Information Technology
BIS	Department for Business, Innovation and Skills
CBI	Confederation of British Industry
CPHC	Council of Professors and Heads of Computing
CRAC	Careers Research and Advisory Centre
DfE	Department for Education
DLHE	Destinations of Leavers from Higher Education
FEC	Further Education College
HE	Higher Education
HEBRG	Higher Education Better Regulation Group
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institution
HESA	Higher Education Statistics Agency
HEPI	Higher Education Policy Institute
IAB	Industry/Industrial Advisory Board
IET	Institution of Engineering and Technology
JACS	Joint Academic Coding System
KIS	Key Information Set (Unistats)
LDLHE	Longitudinal Destinations of Leavers from Higher Education
LPN	Low Participation Neighbourhood
NCUB	National Centre for Universities and Business
NUS	National Union of Students
ONS	Office for National Statistics
PSRB	Professional, Statutory and Regulatory Body
QAA	Quality Assurance Agency for Higher Education

SIC	Standard Industrial Classification
SIVS	Strategically Important and Vulnerable Subjects
SME	Small and Medium-sized Enterprise
SOC	Standard Occupational Classification
STEM	Science, Technology, Engineering, Mathematics
TEF	Teaching Excellence Framework
UCAS	Universities and Colleges Admissions Service
UCL	University College London
UCLAN	University of Central Lancashire
UKCES	UK Commission for Employment and Skills
UKCRC	UK Computing Research Committee
UUK	Universities UK
UWE	University of the West of England

Annex B – Advisory group membership

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The Advisory Group met on the following dates:

30 April 2015

10 July 2015

4 September 2015

21 January 2016

The Advisory Group membership was drawn from a range of PSRBs, HE providers and employers, and employer representative groups, and was tasked with providing advice and support to the Review Lead in the conduct of the review.