The Institute of Coding: Addressing the UK Digital Skills Crisis

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ABSTRACT

The Institute of Coding is a new £40m+ initiative by the UK Government to transform the digital skills profile of the country. In the context of significant national and international education and skills policy scrutiny, it responds to the apparently contradictory data that the country has a digital skills shortage across a variety of sectors, yet the university system produces computing graduates every year who end up unemployed, or underemployed.

In this paper, we describe the background and evidence base for the Institute of Coding, its key themes and current activities, as well as reflecting on potential replicability of aspects of the Institute to other nations or regions with similar ambitions.

CCS CONCEPTS

• **Social and professional topics → Computer science education**; **Information technology education**; **Software engineering education**; **Employment issues**; *Computing industry*;

KEYWORDS

Digital skills, Programming, Computer science education, Undergraduate education, Graduate education, Industry collaboration

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1 INTRODUCTION

We are frequently being told that this is "the digital age", and that we "live in a knowledge economy". From entertainment and communication, via the power and reach of a small number of social networking platforms, with algorithms influencing what we see or making decisions that affect us every day; to education, health and social care, and innovation in public services.

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1.1 Diversity, especially Gender

In 2017, the UK digital sector comprised of 1.5 million jobs (4.6% of the total number of jobs in the UK), the highest number for the sector (and a 16.1% increase) since 2011 [11]. Its workers are more productive, on average, by £10,000 per worker and jobs requiring digital tech skills command higher salaries, at £42,578 compared to £32,477 for those that do not. Despite the stereotype that digital tech jobs are for "millennials", 72% of workers are aged over 35; however, only 19% of the UK digital tech workforce is female [23]. Indeed, the Institute of Coding announcement [14] quoted the even more pessimistic "In 2017, female programmers and software developers made up just 3.9% of tech and telco professionals in the UK".

1.2 Education and Skills Policy

Across the world there are a plethora of initiatives and interventions to address the wider societal challenge, and the corresponding skills shortages [5]. But what do we mean by digital skills? While there is a strong socio-economic policy focus, it should not just be about jobs: we want, and need, a digitally competent, capable and engaged citizenry [24]. Alongside substantial curriculum reform across the UK [4], including a new national curriculum in England [12] and emerging reform in Wales [1], we have also seen significant changes to the available qualifications, based on perceived rigour, content, distinctiveness and modes of assessment. The publication of a follow-up report on computing education in the UK from the Royal Society [20] in 2017 framed some of these national challenges in the context of computing for all, calling for a coherent strategy so that all learners are equipped and empowered with the necessary skills to be effective in the digital world.

However, it is clear that from all of these various reviews, reports, activities, initiatives and interventions, there remains a lack of connectedness and policy coherency – more so when it cuts across ministerial portfolios, or requires multi-year coordinated support. In this keynote paper we frame some of these discrete challenges – and opportunities – and introduce the Institute of Coding, a new £40m+ initiative by the UK Government (but primarily focused on England, with related activity in Wales) to transform the digital skills profile of the country.

2 SO WHAT'S THE PROBLEM?

Superficially, the employment outlook for computing graduates in the UK looks excellent. [25, p. 74] states "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." This is profitable for the individual: according to [9, Figure 4], "mathematical and computer sciences" have the second highest earnings return of all subjects (beaten only by "medicine and dentistry"). The country profits from this as well: according to [9, p. 16], this is, per head, the fourth most beneficial subject to the Exchequer.

Despite the headline success in [9], the employment figures are not great, and the earnings data are patchy.

2.1 Graduate Employment

Quoting [25], the author of a UK Government-commissioned report [22] writes: "In this context, apparently high rates of unemployment[1] amongst graduates of Computer Sciences and other STEM courses demanded an explanation". A significant explanation is "There are notable differences in the characteristics of Computer Sciences entrants compared to entrants in other STEM subjects" [22, ¶2.6]: fewer women, but 50% more mature students; 16% more Black and Minority Ethnic (BME); and 40% more students from backgrounds where people have traditionally not participated in HE (LPNs).

Mature, BME and LPN students all find getting jobs more difficult. However, for those students that do find jobs, the data are better, showing [22, Figure 6] fewer students in "non-graduate jobs" or low-earning jobs than in STEM as a whole.

2.2 Graduate Earnings

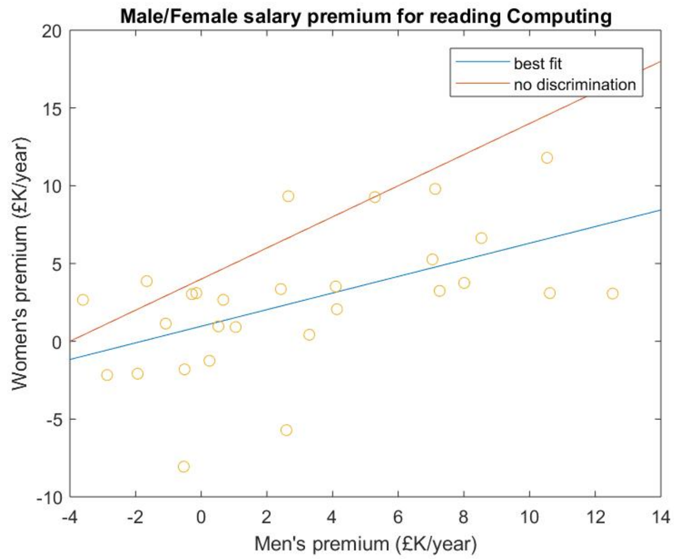
If we look beyond purely getting jobs to the earnings[2], the position (as described in [15], and presented to the public in [2], which also allows the reader to break down the data by university and subject.) is even less clear on a micro level, though on a macro level it bears out much of what [22] said.

On the macro level, the reader should consider [15, Table 5]. We focus on the 'Men' data as presented here, as there are (regrettably) many more than there are women in the cohorts, though the effects are similar. This shows that an OLS ("Ordinary Least Squares") fit shown that a man reading Computing would earn 3.3% more than had he read a subject at random. If one corrects for prior attainment, this rises to 10.5%, and 12.6% if other factors are taken into account. For reasons explained in [15, §4.2], the authors prefer IPRWA ("Inverse Probability Weighted Regression Adjustment"), and this moves the earning difference to 14.4%. For men, the overall effect of these adjustments is to move Computing from being middle-of-the-pack [15, Figure 15] to fourth best [15, Figure 17], and for women it moves to seventh best [15, Figure 16]. Note that these are improvements on the average graduate earnings which are £30,000/year for men and £26,000/year for women [15, p. 37]. Hence if a particular subject were sending students into gender-neutral careers in terms of actual earnings, the women would be showing a 15% (£4,000/year) premium just to catch up with the men.

2.3 Per-University Earnings

[2] allows one to break down the data underpinning [15], and the Computing figures are challenging. Salary premiums, allowing for the factors described above, are reported separately for men and women, and only if there were at least 50 students of that gender in the five cohorts (graduation 2007–8 to graduation 2011-12) considered. This means that, of the 82 English universities reporting computing, 80 report male data and 30 report female data — 28 report both. Looking at the 28 (see Figure 1), one's first impression is that the male and female data are uncorrelated: for example the two universities with male premiums just above +£2500 have female premiums of +£9325 and -£5793. There is in fact a definite ($p = 0.0034$) positive correlation, but a fairly weak one ($R^2 = 0.286$). The best fit is $W = 0.92672 + 0.53388 * M$. For the reasons explained at the end of the previous section, the ideal "gender-neural" fit would be $W = 4 + M$. Both these lines are shown in Figure 1.

Figure 1



3 UK UNIVERSITY POLICY CONTEXT

It is worth recalling that, after the Government's acceptance of the Browne report, students in England pay probably the highest[3] prices in the world for undergraduate education: between £6000 and £9000/year for tuition alone.

3.1 Teaching Excellence Framework (TEF)

UK universities have been judged, very publicly, on their research for the last thirty years by the Research Assessment Exercise (RAE), and its successor the Research Evaluation Framework (REF). This has led to many complaints, largely justified, that teaching, because it is not measured, is not taken as seriously as research, certainly in some of the research-intensive universities. To counteract this, the Government introduced (first grades published in June 2017) a "Teaching Excellence Framework" (TEF)[4].

[1] 11.7% six months after graduation (the standard UK measure) at the time of [22], compared with a STEM average of 8.4%. Note, however, that Computing is 20% of STEM, 1]Wakeham2016a, so 'STEM-less-Computing' has a 7.6% unemployment rate.

[2] Clearly not the only measure of job quality, or contribution to society, but at least it's measured in the LEO dataset [13], which tracks individuals through school, university and into the labour market, combining educational, tax and benefits data.

[3] Or possibly second-highest after US students, but the US averages in [18, Table B5.1] conceal an enormous variation.

[4] Now renamed "Teaching Excellence and Student Outcomes Framework", which is somewhat more descriptive.

3.2 Degree Apprenticeships

The Government has also launched "Degree Apprenticeships" [10]. These were described by the then Prime Minister as "combining a full degree with the real practical skills gained in work and the financial security of a regular pay packet". The employer pays the tuition cost, but due to the Apprenticeship Levy, essentially a 0.5% payroll tax, large (payroll over £3M) employers will find there is no net cost, while smaller employers can claim 90% of the cost from the Government. Degree Apprenticeships can be either Level 6 (BSc level) or Level 7 (MSc level). The Level 6 ones last 3–5 years, typically 4. The Goverment has just (7 August 2018) approved the details of Level 7 ones, so not much can be said.

4 SKILLS MISMATCH

There is a widespread and longstanding complaint that "students aren't industry-ready", or "there is a skills mismatch". Some of this is due to a misapprehension on the part of employers – and perhaps misunderstanding of the nature of education versus training, but much of it is genuine. Previous work in this space has focused on the evidence based for how programming and software engineering is taught at degree level [8, 17, 21]. One of the main challenges for the university community is to better understand this complaint.

4.1 Sandwich Years

In the UK context, a university course that includes a period working in industry (which may include government, charity etc.) is generally called "sandwich", and in North America the term "co-op" is generally used. The most common model in Computing in England, where the vast majority of students study three-year Bachelor's degrees, is a year's placement in industry between the second and final years of study. This is remarkably successful in computing. Bath has run such courses since its founding (1966), with about 80% of students opting to take the sandwich year. There is statistical evidence for its success wherever it is used in the UK: 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. [22, ¶2.5].

A simplistic remedy would be to require that all students study sandwich degrees, but this has numerous objections:

i) Some students do not wish to, often for valid reasons;
ii) The supply of employers willing to offer such placements is limited, and often they are only offered to a limited number of universities with whom the employer has built up relations, often going back decades;
iii) The university needs to invest in the process: a successful sandwich year programme is not a matter of simply allowing students to intermit their studies.

Hence we should ask ourselves *why* such courses are so successful. There are, it seems to the authors, two classes of reasons: those intrinsic to the sandwich process, and the skills the sandwich process confers. The first class is easy to understand: the employer can view the year as a year-long assessment phase before deciding whether to offer a permanent job. However, it is the second class that we need to investigate in the hope that non-sandwich courses can learn from them. A major one, brought out repeatedly by students returning from placement, is team working.

4.2 Team/Group working

"Teamwork" is often identified as a key skill. Simplistically, then, universities should teach it. Indeed, the British Computer Society has long required this of degrees it accredits: "An ability to work as a member of a development team recognising the different roles within a team and different ways of organising teams [3, Requirement 2.3.1]." The problem is that group working is unpopular with students. Most of them have never experienced it in their academic work at school, and really dislike "being dragged down", as they generally put it, by others. In many countries, this wouldn't matter, but the UK has the National Student Survey. As well as the quantitative scores, the students submit free-text responses, and it does not take many students complaining about the group work before the Pro-Vice-Chancellor (Teaching) or equivalentis beating down the Director of Studies door, saying "obviously you must abolish groupwork immediately".

However, a BCS-accredited course gives the response "but our accreditation demands it", whereupon the discussion can evolve into a more sensible debate about the size, shape and process of group working. This leads to a curious paradox. Employers value group working experience (at a Shadbolt Review focus group, every employer stated they always asked potential employees about experience of group working), group working experience is only taught because accreditation requires it, but employers do not value accreditation. "systems of accreditation more broadly are poorly understood and valued by employers, students and HE providers" [22, ¶2.12].

5 INSTITUTE OF CODING

The Institute of Coding is one of the UK Government's latest responses to the "Digital Skills Challenge". The Institute brings together a consortium of research- and teaching-focused universities, large corporates, small- and medium-sized enterprises (SMEs), established industry groups, experts in the delivery of distance/non-traditional learning and professional bodies to develop and deliver innovative, industry-focused education across the UK. It is explicitly an industry–university collaboration, with the Government contributing at most 50% of the money.

It brings together for the first time traditional computer science departments and business schools, leaders in art and design, innovation in programme delivery, the industry backing of the UK's leading digital employers, and the leading professional bodies. The Institute's vision is that "every student leaves education with employment, and that employers and individuals across the UK have ready access to the skills they need to compete successfully in the global digital economy". It is structured around five themes:

1. University Learners: This is aimed at understanding, and solving, the "Skills Mismatch" problems. These problems can be quite subtle, and are not addressed by such broad requirements as [3, Requirement 2.3.1]. Hence the Institute is also looking at accreditation, with a view to producing more detailed records, essentially e-portfolios, of skills achieved. It is possible that these will be supported by a blockchain-based mechanism, as is being done elsewhere [19].

2. The Digital Workforce: In practice this is largely aimed at degree apprenticeships (see §3.2). These are still in their very early days in computing, and we hope that the Institute will enable best practice sharing from the beginning. In terms of content, as opposed to pedagogic practice, this theme is tightly linked with theme 1, notably in areas like cybersecurity, where there is a great shortage of non-proprietary teaching material.

3. Digitalising the Professions: The official description "to transform professions undergoing digital transformation" [14] is tautologous, but the consortium aims are to provide a flexible modular digital masters programme aimed at people in various professions where digital technologies are changing the job such that serious upskilling in necessary, and also to provide various short taster courses in order to widen the reach of digital skills. As for theme 2, this will be sharing content with theme 1.

4. Widening Participation: This is aimed at the problems identified in §1.1. Since the Institute bid was submitted, the salary data in [15] (see Figure 1) have been released, which show the importance of a more nuanced study of the effect of gender in particular. The analysis in [15] concentrated on gender, but we are hoping to do similar studies for computer science with regard to other characteristics such as ethnicity.

5. Knowledge Sharing and Sustainability: A perverse, but totally natural, consequence of the REF has been the marginalisation of pedagogy research in the UK [7]. This is particularly acute in Computing; dissemination of good practice is also low: [17] was the first survey of its kind in the UK, despite the fact that they had been running for many years elsewhere [21].

Delivering as much education as the Institute proposes presumes a supply of educators; this is a major challenge at all levels for computing in the UK [4, 16], as it is in many countries. Hence one workpackage in this theme is devoted to "educating the educators".

A further challenge is sustainability. The UK Government funding for the Institute is short-term, and indeed will lapse before anyone graduates from a Level 6 (BSc) degree apprenticeship. Hence the Institute needs to become self-supporting in a very short timeframe.

6 FUTURE WORK AND REPLICABILITY

We have seen – and will continue to see – a number of successful initiatives, activities and interventions which may prove useful to other nations reforming their curricula (both compulsory, school-level, as well as post-compulsory), as well as in the wider aim of developing broader societal digital skills.

The Institute of Coding is very much "work in progress": at the time of writing it was just over nine months old. The mere adumbration prompted the research in [17], and the various working groups round the themes are causing more discussion of computing pedagogy in the UK than the authors can ever remember, further reinforced by the recommendations in [20]. In particular, it is providing a vehicle for better industrial engagement (as in [6]).

The Institute of Coding could thus provide a national cohering role, collaborating with other organisations working on school-level interventions (such as Computing At School (CAS), Raspberry Pi Foundation, Technocamps, *et al.*), providing a platform for conducting research and evaluation activities; building the evidence base and informing policy; supporting accreditation and standards; as well as changing the wider perception – and economic, societal and cultural importance – of 'ICT', 'digital', 'coding', etc.

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