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TOWARDS A SUSTAINABLE SOLUTION TO THE SHORTAGE OF COMPUTING TEACHERS IN SCOTLAND

Judy Robertson, November 2019

ACKNOWLEDGEMENTS

EXECUTIVE SUMMARY

Learners in Scottish schools deserve high quality teaching about computer science so that they have the opportunity and skills to participate in Scotland's digital economy. Scotland's digital sector is growing fast, contributing £4.9 billion (GVA) to the Scottish economy and employing 100,000 people[1]. However, as around half of Scottish employers in the digital sector report difficulty in recruiting to fill their digital skills gaps, it is clear that the education system needs to do more to support talent development in computing. One barrier to achieving this is the current shortage of computing teachers in Scotland. For the last three years, the target numbers identified by Scottish Government for student computing teachers on initial teacher education (ITE) courses have not been met. There are currently 595 computing teachers in Scotland, whereas a decade ago there were 766 (22% fewer)[2].

Co-ordinated action is required to sustainably address the shortage of computing teachers. We present recent research, commissioned jointly by University of Edinburgh and with grant support from Skills Development Scotland, which explores why computer science graduates do not choose to become computing teachers, and what might persuade them to pursue this career. We conducted a literature review, a survey of recent computer science graduates and focus groups with current computer science students. This research focuses primarily on the recruitment of new teachers; future work could consider the retention of existing teachers. Our research highlights that:

- *The problem isn't too big to tackle*. We require between 50 and 60 new computing teachers per year, whereas our Universities produce in the order of 5,000 computing graduates per year.
- *There is a group of qualified individuals who could be persuaded to become computing teachers*. 44% of recent computing graduates who took part in our survey said computing teaching was "quite a good", "good" or "great" career option.

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[1] https://www.skillsdevelopmentscotland.co.uk/media/43306/scotlands-digital-technologies-summary-report.pdf

[2] https://www2.gov.scot/Topics/Statistics/Browse/School-Education/teachcenssuppdata/teasup2018

- *Computing students value good teaching.* Participants in the focus groups spoke about how they had been inspired by their teachers and recognised the value of teaching to society. They felt that the teaching profession is now less respected in society that in previous times.
- *Concerns about pay and conditions are complex.* Many participants were concerned about what they perceive to be low pay for teachers. However, there is a wide range of starting salaries within the IT profession, and this varies by geographical region. Current initial teacher salaries are comparable to the lower end of IT graduate starting salaries, particularly considering the 13% pay increase for teachers which was agreed in March 2019. Participants considered other aspects of the working environment to be important too, such as working hours, job related stress and autonomy.
- *Flexible work options make computing teaching more attractive.* Survey respondents said that teaching for 2-3 years (rather than their entire working life) would make it a more attractive option (47%) and 80% considered part-time options more attractive. This is consistent with focus group participants' views.
- *Computer science graduates want to keep their technical knowledge up to date.* Participants emphasised the importance of continued professional learning and personal development.
- *Computing teaching careers are not visible when students make their career choices.* Computer science students are actively "courted" by industry but they do not hear about the teaching profession at careers events. Their attitude to this career is shaped by their own school experiences (which unfortunately were sometimes negative), and some influence from friends or family.

We propose a short-term plan for improving communication about computing teacher career routes, and a medium to longer term plan to open up flexible routes into computing careers. We believe it would be most effective for national stakeholders – including government agencies, GTCS, universities, IT employers, and learned/professional societies – to work together to solve this problem.

- In the short term, *we recommend a relatively low-cost project to improve communication about computing career options* including a positive campaign to promote computer science teaching careers among computer science university students. We believe that face to face presentations by enthusiastic computing teachers at university careers events could be effective, along with a well-designed website to present factual information.
  In the medium to longer term:
- *We recommend opening up more flexible routes into computing teaching, each step of which introduces more computing experts into the classroom to perform a useful role.* We believe that computer science undergraduates should have the opportunity to help in classrooms, and should be rewarded for doing so. There should also be structured routes to make the most of the valuable contributions from software industry volunteers. We recommend more flexible (perhaps part-time or distance) initial teacher education courses in this subject.
- We propose the introduction of a *computing expert role for classrooms*, similar to the British Council's language classroom assistants where experts are paid on a part-time basis to work alongside computing teachers, helping children to learn challenging and up to date topics.
- We also recommend that teaching jobs should be more flexible (supporting braided careers), and offer more opportunities for up to date professional learning.

THE CURRENT LANDSCAPE IN SCOTLAND

TEACHING IN SCOTLAND – PAY AND CONDITIONS

Teachers in Scotland are contracted to work a 35 hour week, with no more than 22.5 hours per week spent in class contact time. They work for 195 days a year, (including 5 days of in-service training) with 40 days of paid leave. Currently in the probationary year, teachers are paid £26, 694 p.a., moving up to 32,031 in their second year of teaching[3].A teacher moves up the salary scale one point with every year of service. In March 2019, a pay increase of 13% for teachers over 3 years was agreed, as shown in the current and revised teaching salary scales in Table 1.

Current Pay Point	Jan-18	Apr-18	New pay point	Apr-19	Apr-20
		3%		7%	3%
0	22,866	23,553	0	26,694	27,495
1	27,438	28,260	1	32,031	32,991
2	29,064	29,937			
3	30,714	31,635	2	33,849	34,866
4	32,499	33,474	3	35,817	36,891
5	34,557	35,595	4	38,088	39,231
6	36,480	37,575	5	40,206	41,412

Table 1. Current and revised teacher salary scales in Scotland [source: https://www.eis.org.uk/Value-Education-Value-Teachers/NewSalaryScales]

A 2018 survey of 1395 members of the teaching workforce in Scotland (conducted before the conclusion of the pay negotiations) found that teachers' morale is low, work-loads are high, and there is a perceived lack of clarity on policies relating to professional development. Participants felt that their profession was undervalued by society, although they were proud of their own work. [4]

COMPUTING TEACHING IN SCOTLAND

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[3] https://www.eis.org.uk/pay-and-conditions-of-service/salary-scales

[4] https://www.nasuwt.org.uk/uploads/assets/uploaded/c5738dce-f321-424c-911e45b25112aaf0.pdf

Data published by the Scottish Government[5] about target and actual recruitments to initial teacher education programmes in computing indicates that there has been a shortfall over the last three recruitment cycles (see Table 2).

	2018/19	2017/18	2016/17
Target places on secondary computing teacher courses	55	60	52
Places filled on secondary computing teacher courses	46	41	41
Shortfall	-16%	-32%	-21%

Table 2. Target and actual student computing teacher numbers

This information continues the historical trend. There are currently 595 (259 female, 336 male) computing teachers in Scotland, whereas a decade ago there were 766 (22% fewer)[6]. This has been a steady decline, with a small increase of 13 in the last year. In a 2016 report, Computing at Schools Scotland raised the concern that 62 secondary schools in Scotland (17%) didn't have computing teachers, and that 47% of local authorities reported difficulties in recruiting them. There were 4099 candidates for the SQA Higher Computing qualification in 2018 (a reduction from the previous year)[7]. There has been however been an increase in entries and passes at Advanced Higher level during this time, albeit overall numbers are smaller (636 entries in 2018). A decade previously there were 4256 candidates for Higher Computing. The decline in teacher numbers is considerably steeper than the decline in learner numbers.

In order to become a computing teacher, the General Teaching Council Scotland requires that applicants have an 80 credit degree which contains 40 credits from second year university (or above) in two of: software systems; software development; information systems or databases. A 36 week full time postgraduate diploma in education (PGDE) course is offered by Glasgow, Strathclyde and UHI. Stirling University offer a four year degree in education plus computing and maths or business. There is an option to study the computing pathway in the two year MSc in Transformative Learning and Teaching at the University of Edinburgh. More flexible study options include an 18 month part-time distance learning PGDE at Aberdeen, and a one year financially supported PGDE course at Dundee. Although the Teach in Scotland website lists these flexible study routes, the links to these courses were broken at the time of the focus groups conducted for this report[8], making it difficult for applicants to find the information they need.

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[5] https://www.gov.scot/publications/initial-teacher-education-figures-2016-2018/

[6] https://www2.gov.scot/Topics/Statistics/Browse/School-Education/teachcenssuppdata/teasup2018

[7] https://www.sqa.org.uk/sqa/63001.html

[8] https://teachinscotland.scot/secondary/computing/

SCOTTISH GOVERNMENT'S APPROACH TO RECRUITING TEACHERS

In 2017, The General Teaching Council Scotland[9] identified a series of challenges which prevent the recruitment and retention of teachers of all subjects in Scotland including the public's less than positive perception of the teaching profession and the lack of campaigns which portray teaching as a positive career; the perception of teacher salaries as less than other professions (note that this work was published before the pay settlement); lack of permanent contracts for new teachers; difficulties in recruiting to rural areas; lack of support for those who might wish to return to teaching or pursue a second career in teaching; and inflexible initial teaching education courses.

The Scottish Government's strategy to addressing shortages in the teacher workforce has various aspects: faster and more flexible routes into the profession, teacher recruitment campaigns and bursaries to incentivize people with STEM backgrounds to become teachers. The Deputy First Minister reported at the end of 2018 that these had been measured had resulted in sustained increases in student teacher intakes over the previous three years (including in the STEM subjects) and reduced teacher vacancies[10]. Since 2017 to the end of 2018, teacher vacancies in primary schools fell from 307 to 49, and from 507 to 148 in secondary schools.

In 2016, the Scottish Government announced a series of eleven new routes into teaching in order to encourage 200 new teachers into the profession[11]. The routes included assistance for teachers to return to the classroom and plans to get new STEM teachers into the classroom quickly. Scottish Government also ran the "Inspiring Teacher" and "Teaching Makes People" teacher recruitment campaigns, attributing the 19% increase in overall PGDE applications in 2016 to the success of the former. In addition to billboard adverts, radio and targeted digital advertising, there was a "Teaching Makes People" stand at 11 university careers fairs encouraging undergraduates to consider teaching careers. Almost 3,500 people visited this stand, with 1,090 spending time discussing a career in teaching, and 40% of people who had seen the campaign video took some action, such as seeking further advice teaching careers[12].

Scottish Government bursaries are available for those who want to become teachers in STEM subject including computing[13]. The bursary, first available for those entering initial teacher education courses in August 2018, provides a £20, 000 bursary (or £14,000 payment for those undertaking the PGDE with Masters course at Strathclyde University). The scheme is designed to support people who have at least 36 months paid employment to make a career change into teaching. As this scheme is recent, it is hard to evaluate its longer term impact although initial results are promising. In 2018/19, 107 bursary places were filled (target 100). Of these, 11 were for computing teacher courses (5 female, 6 male students)[14]. The increase in computing teacher numbers in the last year is predominantly accounted for by those studying on STEM bursaries.

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[9] http://www.parliament.scot/S5_Education/Inquiries/20170427GTCS-SubmissionTeacherWorkforce.pdf

[10] https://www.gov.scot/news/more-teaching-vacancies-filled/

[11] https://news.gov.scot/news/new-routes-into-teaching

[12] https://news.gov.scot/news/teacher-campaign-impact

[13] https://stembursaryscotland.co.uk

[14] https://www.gov.scot/binaries/content/documents/govscot/publications/minutes/2019/03/stem-bursary-advisory-group-papers/documents/stem-teacher-bursary-first-year-review/stem-teacher-bursary-first-year-review/govscot%3Adocument/STEM%2Bteacher%2Bbursary%2B-%2Bfirst%2Byear%2Breview.pdf

CAREERS FOR COMPUTER SCIENCE GRADUATES

There are over 17,000 computer science students currently studying at Scottish Universities, a figure which has grown by 20% since 2014-15. In 2018-19, 5,200 students graduated with computer science degrees from 14 Scottish universities [15]. Computer science graduates are highly employable, with a 84% employment or further study rate for graduates six months after graduation.

The number of computer science graduates each year is a lower bound for the potential pool of new computing teachers– there will be more graduates who meet the GTCS 40 credits in computing subject specification, in addition to career changers who are not recent graduates. To meet the Scottish Government target of recruiting 55 new student computing teachers last year, only around 1% of computing graduates would have needed to opt to become computing teachers.

New computer science graduates across the UK command an average salary of £25, 000 but with a very wide range from £17, 000 to £70,000[16]. ScotlandIS reports on salary ranges for a number of roles which require computer science qualifications – for example a junior software developer could attract an average salary between £26,250 and £35, 000[17]. Figure 1 and Figure 2 respectively compare average teacher and software developer salaries in 2019, and in 2020 when the final stage of the pay agreement for teachers has taken effect. The role "software developer" was chosen as an illustrative role for which a computer science degree prepares graduates, but it is by no means the only one. The data for software developers is drawn from all categories of developer roles in the Scotland IS report, but not those which appear to be management or leadership focussed. For comparison purposes in this report within the teaching profession "junior" refers to 3 or fewer years of experience, "medium" refers to 4 or more years of experience on the main teacher pay grade, and "senior" refers to teachers on the Principal Teacher pay scale. Although both senior software developers and senior teachers may have elements of leadership in their role, it is not the primary focus of their role.

Teacher salaries are below the average salary for software developers, although they are well within the expected range. However, potential earning power in the longer term is higher within the software industry. The gap would be less for teachers in promoted posts (beyond Principal Teacher which is shown in these graphs) working on the pay scale for deputy or headteacher. Additionally, employees within the IT sector may receive other forms of remuneration such as health care or shares. It should also be noted that the newly qualified teacher has undertaken an additional period of study, and so will be behind peers in their graduating class in terms of initial earning power.

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[15] https://www.skillsdevelopmentscotland.co.uk/media/43306/scotlands-digital-technologies-summary-report.pdf

[16] https://www.savethestudent.org/student-jobs/whats-the-expected-salary-for-your-degree.html

17 https://www.be-it.co.uk/blog-news/view/5470/the-2018-19-be-it-salary-survey.aspx

Comparison between teacher salaries and software developer salaries in Scotland 2019
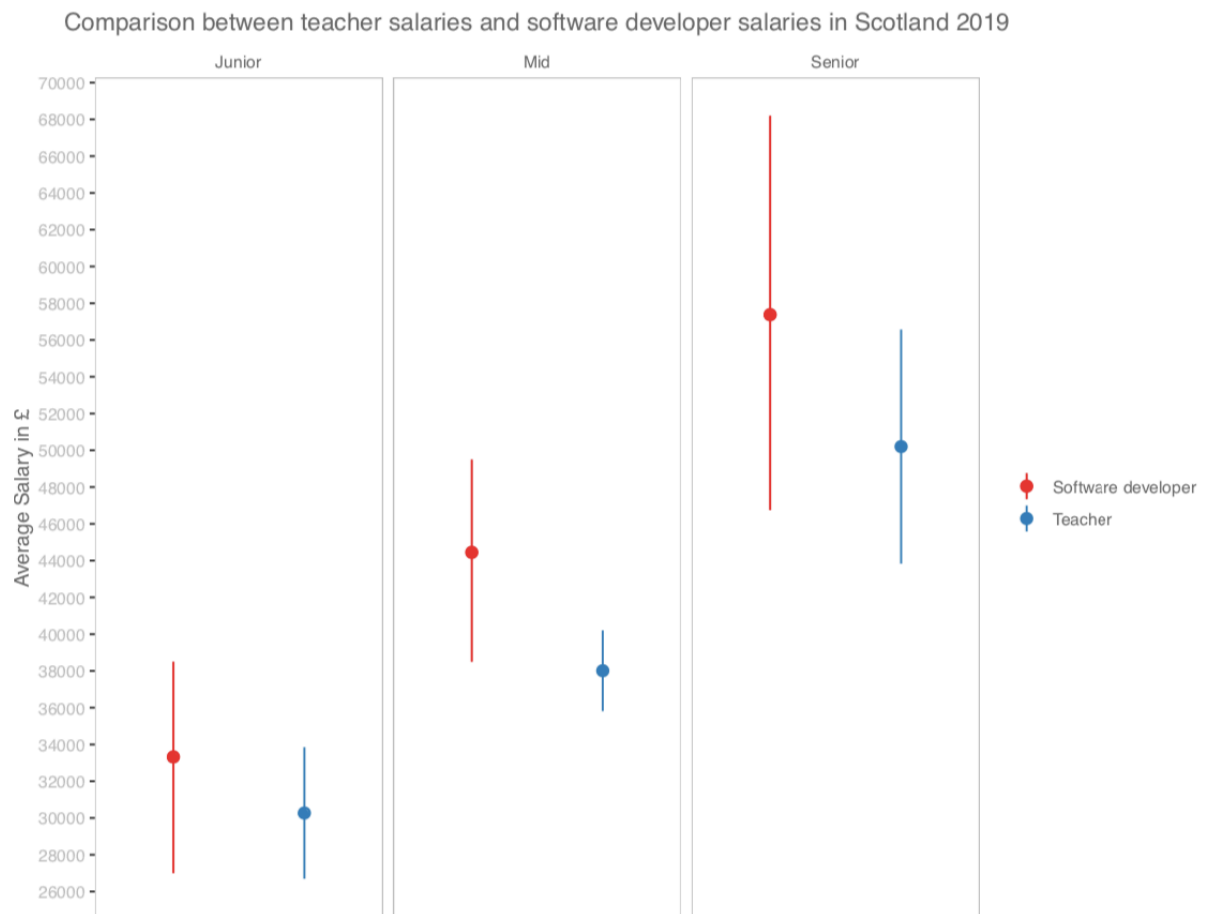
Figure 1. Comparison of current teacher and software developer salaries in Scotland 2019. Assumption: For the teaching profession, "junior" refers to 3 or fewer years of experience, "medium" refers to 4 or more years of experience on the main teacher pay grade, and "senior" refers to teachers on the Principal Teacher pay scale. Although both senior software developers and senior teachers may have elements of leadership in their role, it is not the primary focus of their role.

Comparison between projected 2020 teacher salaries and software developer salaries in Scotland
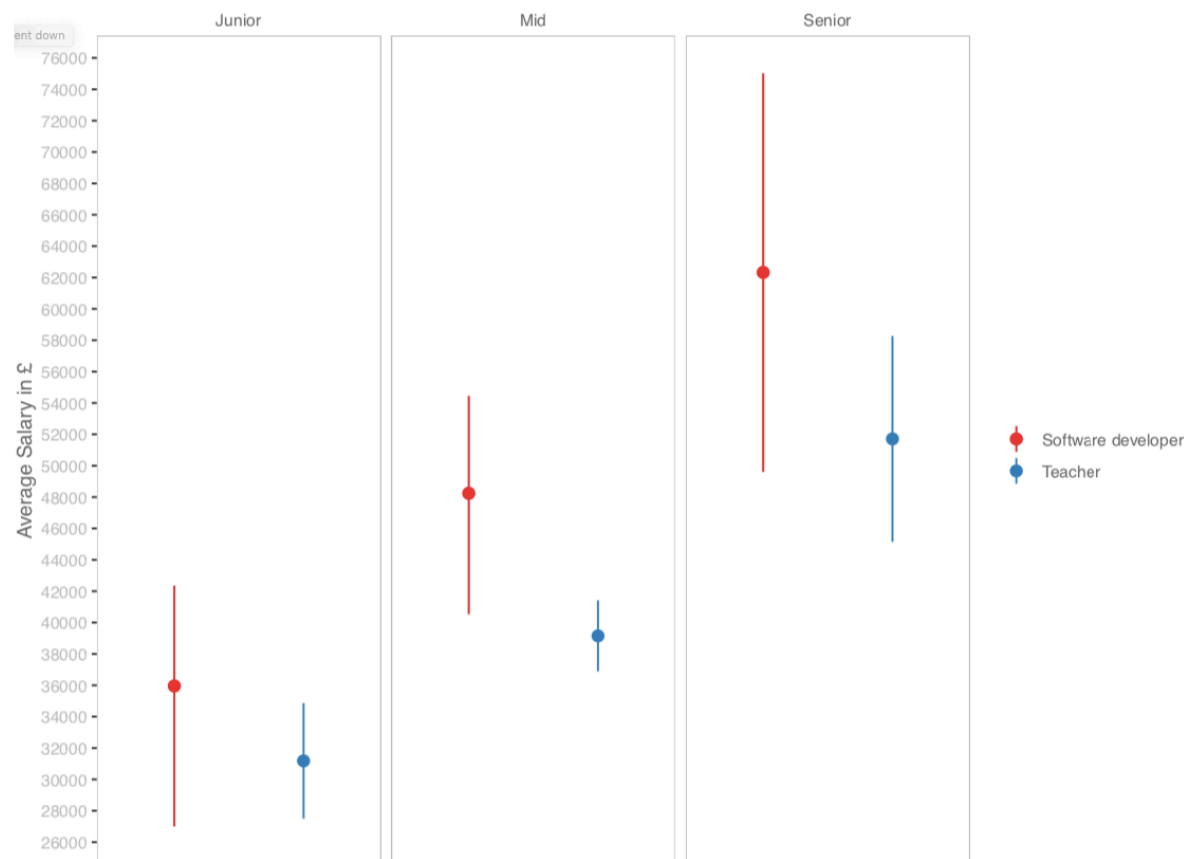
Figure 2. Comparison of 2020 projected salaries. Assumption: software salaries will increase by the same percentage per year from 2019 to 2020 as they did in the previous year.

In summary: there is considerable variation in the salaries of those working in computer science related professions which precludes a straightforward comparison with the national pay scales for teachers. However, comparison with the average salaries for software developers in the first three years indicates a difference in the order of £4,000 p.a. in the favour of industry employment. Comparisons become increasingly difficulty as career paths diverge because some individuals specialise or earn promoted posts, but software industry careers are generally better remunerated.

RELATED RESEARCH

INTERNATIONAL COMPARISONS OF COMPUTER SCIENCE IN SCHOOLS

Scotland is not alone in striving to improve computing education in school: the goal is common across England, the rest of Europe, the United States, and in other countries across the world. National and international computer science education advocacy groups, such as the Royal Society, the Association of Computing Machinery, and Code.org argue that improvements in computer science education at school require a curriculum which includes the intellectual discipline of computer science, and a supply of suitably qualified teachers to increase equitable availability of computer science classes to everyone.

Scotland is performing relatively well in these areas in comparison to other countries. We have offered specialist computing qualifications to high school learners for many years, and computer science has been part of the Curriculum for Excellence since 2016 for learners aged three and upwards. Because of this, all learners across the country have access to computer science education in theory; whether this is true in practice depends on the extent to which the learner's school provides teachers who are familiar with the new aspects of computing at primary level, or specialist computing teachers at secondary level. In turn, this is related to the provision of professional learning for teachers currently in the work force, and the recruitment of sufficient numbers of suitably qualified applicants for initial computing teacher education programmes. Scottish computing teachers must have studied computer science courses at university, as well as undertaking a university qualification in teaching. This is an advantage because it sets a reasonably high quality threshold for teachers who are knowledgeable in both computer science content knowledge and pedagogy. The trade-off is that it reduces the pool of potential computing teachers. Different countries across the world have different approaches to managing this issue.

Computing science teacher upskilling is now a priority within England: the government has committed £84 million to upskill 8,000 teachers in the period up to 2022/23[18]. Computer Science, digital literacy and ICT topics have been mandatory in the curriculum for 5-16 year olds in England since 2014. Despite this, the Royal Society's recent report on computing education identifies that the computing education in the UK is "patchy and fragile"[19]. A key conclusion from the report is that "More research is required to understand how to make computing teaching careers more appealing, especially when the incentives within industry are so strong". Although both Scotland and England face challenges in recruiting computing teachers with appropriate qualifications, there are variations in the nature of the challenges. It is worth noting that in England, only 36% of computing teachers are CS graduates[20] because there is not a requirement to study computing at university level as there is in Scotland. Despite Scotland's requirement to recruit applicants who have higher formal subject qualifications, it has similar success rates in meeting computer science teacher recruitment targets to England. In 2017/18, 68% of the Scottish target for recruiting to PGDE programmes for computing was met in contrast to general PGDE places for which 70% of the recruitment targets were met.[21]. In England, 68% of the target places were filled for computing teacher training, which was the poorest performing subject area for recruitment[22]. In comparison to other STEM disciplines, in Scotland, physics slightly outperformed computing, with 73% of the target for PGDE recruitment met, while maths fared considerably worse with only 47% of target numbers recruited. The same pattern did not hold in England, where 84% of maths and 81% of physics recruitment targets for initial teacher training were met. Given these contrasting patterns of recruitment, policy makers in the two countries may prioritise recruit of teachers of subject specialisms differently.

In the US, computer science education has received more attention since President Obama started the *Computer Science for All* initiative in 2016. More recently, President Trump has allocated $200 million in grants for computing initiatives in schools[23]. While there is strong support for improving CS

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[18] https://dera.ioe.ac.uk/30959/

[19] https://royalsociety.org/~/media/policy/projects/computing-education/computing-education-report.pdf

[20] https://royalsociety.org/~/media/policy/projects/computing-education/computing-education-report.pdf

[21] https://www.gov.scot/publications/initial-teacher-education-figures-2016-2018/

[22] https://publications.parliament.uk/pa/cm201617/cmselect/cmeduc/199/199.pdf

[23] https://drive.google.com/file/d/1DXgpLjl_k87TVpQ0cLusfdjnYySIgIjT/view

education in schools from teachers[24] and parents[25], computer science is only available in 35% of high schools[26]. The *Code.Org Advocacy Coalition* identify that the shortage of suitably qualified teachers is hampering the effort to expand computer science education offerings[27]. Because computing education became a priority relatively recently in the US, many states have no policies regarding certification to teach computing and there is a need for additional institutions to offer qualifications in computing teaching. Across the entire United States, only 75 teachers graduated from universities equipped to teach computer science in 2016, compared to those who qualified to teach maths (12, 528) and the sciences (11,917)[28].

Across Europe, Informatics (the intellectual discipline which encompasses computer science) is available to all students in 44% of countries, and in an additional 20% of countries, it is available to a subset of students[29]. Eighty-seven percent of the countries require a specialist qualification to teach computer science. However, the availability of well qualified teachers is identified by the organisation *Informatics Europe* as a major problem in many areas. Informatics Europe emphasises that it is important that teachers have both informatics content knowledge and specialist knowledge of informatics pedagogy. They therefore caution against the idea of improving informatics education by having computing professionals co-teach in schools without any additional training. In contrast, the Royal Society identified that "schools and teachers need ready and easy access to the expertise in industry and academia. They need computing experts to give them advice about the curriculum. They need people willing to spend time in the classroom, supporting their teaching" (p64). There is spectrum of models by which computing experts can assist in the classroom, from "co-teaching" which implies shared responsibility between IT professionals and teaching professionals to arrangements where teachers get expert advice on the CS content of their materials. This issue is further addressed in the Proposed solutions section of this report.

BARRIERS AND ATTRACTORS TO STEM TEACHING CAREERS

Although there has been little research on what might motivate or deter people from becoming computer science teachers, the literature documents potential incentives and barriers to people choosing STEM teaching careers in general.

The FIT-Choice model (Watt. et al., 2013) considers the factors which influence people to choose a teaching career. It traces how people consider social influences such as their own prior learning and teaching experiences, or social dissuasion, in conjunction with their perception of the tasks demands and returns of the job, how they perceive their own teaching abilities, and their estimation of the intrinsic value of the job.

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[24] https://www.edsurge.com/news/2018-12-03-in-a-new-survey-teachers-say-there-s-a-disconnect-in-computer-science-education

[25] https://www.edsurge.com/news/2018-08-29-survey-says-parents-think-tech-companies-should-help-build-kids-digital-skills

[26] https://code.org/files/2018_state_of_cs.pdf

[27] https://code.org/files/2018_state_of_cs.pdf

[28] https://medium.com/@codeorg/universities-arent-preparing-enough-computer-science-teachers-dd5bc34a79aa

[29] https://www.informatics-europe.org/working-groups/informatics-education.html

Validation of this model comes from a series of international studies. For example, a study of the motivations of 245 Australian student teachers, particularly those specialising in STEM and ICT, found that participants were motivated to teach because they believed they had an aptitude for it; they believed in the social utility of teaching (shaping the future, increasing equity, working with children); and had personal reasons relating to the structure of the job (such as job security, or time for family). They indicated that while positive previous experiences with teaching and learning were a motivator, they had also encountered social dissuasion from becoming teachers. The student teachers thought of teaching careers as being demanding with relatively low return in terms of high workload, strong emotional demands, and a requirement for deep expertise in exchange for relatively low salary and social status. In spite of this, they were generally satisfied with their career choices (Watt, Richardson, & Pietsch, 2009). Results from a similar Australian study also suggest that some STEM teachers chose their career as a fallback option , perhaps because teaching was seen as less demanding than high pressure STEM jobs, or because it is more compatible with family life (Watt. et al., 2013). In this study, those who chose teaching as a fallback option were more likely to report negative interactions with their students.

Another driver for choosing to become a subject specialist teacher could be a passion for promoting one's academic discipline and sharing knowledge of it with young people. The Royal Society "After the Reboot" report identifies that only 6% of computer science graduates have embarked on a career in education, compared with 11% for physics and 12% for mathematics. A Pearson study of teachers in England in 2015 found that ICT teachers also have one of the lowest levels of being motivated by subject interest (48%), less than Maths and Science, and compared to History at 86% [30]. This suggests that people with a background in computing are less likely to choose to be teachers, and those who have chosen to be ICT teachers were not necessarily attracted by the prospect of sharing their subject expertise.

The barriers and attractors identified in the STEM teaching literature- social influence, task reward, task demands, self-perceptions, intrinsic value of teaching, interest in specialist subject knowledge – were used to develop the survey questions and these themes emerge from the analysis of the focus groups.

BALANCING RECRUITMENT WITH RETENTION

There is a trade-off between incentivising a wider range of people to try teaching and successfully retaining them in the profession for the longer term. Ideally, schools should have a mixed profile of teachers with various levels of experience because teachers with more experience are by and large more effective.

Bursaries can work well to increase applications, as seen in the section about Scottish Government's approach to recruiting teachers. This is consistent with evidence from England. The Department for Education in England analysis indicates a correlation between teacher training applications and bursaries; increasing the bursary by £1000 resulted in a 2.9% increase in applications[31]. However, the National Foundation for Educational Research recommend that the bursaries should be restructured

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[30] https://www.pearson.com/corporate/news/media/news-announcements/2015/10/why-teach--new-research-explores-why-people-choose-to-go-into-te.html

[31] https://dera.ioe.ac.uk//31744/

to incentivise retention after leaving teacher training[32] because it is problematic if new teachers leave the profession before they reach high levels of teaching competence. There is a similar issue with the Teach For/Teach First family of programmes which encourage high performing graduates across the world to commit to teach for a relatively short period of time (such as two years). Teach For/First students enter the classroom quickly after 6 weeks of basic training, and are often placed in schools in disadvantaged communities. While there is not a Teach First route into teaching in Scotland, the principle of encouraging individuals to become computing teachers as a short-term career is worth considering, given the difficulties recruiting teachers for this subject.

In considering this idea, it is important to review studies of Teach For/First teach schemes. While there has been concern that placing inexperienced graduates in schools to begin teaching very early would have a negative impact on children and young people's learning, analysis indicates that in fact there is a consistent small positive effect on learner GCSE results (Allen & Allnutt, 2017). Teach First is more expensive than other teacher training routes[33] partly because of higher drop out rate (between 57%-63% of Teach First teachers choose to remain teaching in a state school for a third year, in comparison to 64%-70% of PGCE trained teachers) (Allen & Allnutt, 2017).

What is the impact of losing teachers from the workforce after a few years? Studies from the United States reviewed in a Learning Policy Institute report from 2016 indicate that teacher effectiveness changes over time with a steep learning curve in the initial two years of teaching. After the first two years, teachers still continue to become more effective as their careers progress although the gains are not as rapid as the initial period (Kini & Podolsky, 2016). Experienced teachers not only benefit students' learning outcomes, but also other success indicators such as attendance, and their work positively impacts the learning outcomes for students taught by other teachers at their school. The Learning Policy Institute recommends that policy makers should develop policies both to attract high quality teachers into the profession, and to reduce teacher turnover. They suggest that policy makers can retain teachers by increasing opportunities for inexperienced teachers to collaborate and learn from more experienced teachers in the same subject discipline. In the context of computer science teaching in Scotland, this requires some creativity and flexibility because there are now many schools which have solo computing teachers. The report recommends that schools should aim for a blend of experienced and less experienced teachers, partly because younger teachers may bring fresh knowledge of technology to the school. This is particularly required in a fast-moving discipline such as computer science. Based on these recommendations, an appropriate strategy would be to welcome and acknowledge the strengths of new recruits into computing teaching, while celebrating and sharing the expertise of existing teachers. The surveys and focus groups were designed to find potential CS teachers' perspectives on short term teaching careers.

WIDER SOCIETAL CHANGES IN CAREER PATTERNS

The previous section considered the impact of short-term teaching careers on the learners' outcomes, from the perspective of benefiting society as a whole. However, career decisions are made by individuals, who factor in a range of potential personal benefits. Although the teacher workforce in

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[32] https://dera.ioe.ac.uk/30960/

[33] https://www.ifs.org.uk/uploads/publications/comms/r100.pdf

Scotland is relatively static, the labour market in general is in a period of rapid change. Individuals work for longer, possibly switching between several different careers throughout their lives (Callanan, Perri, & Tomkowicz, 2017). Currently, only 16% of teachers in Scotland work part-time[34] . Teachers in Scotland tend to stay in their jobs for a long time (a study in 2011 found that 29% of Scottish teachers had been in their jobs for 20 years, and there is a low transfer in or out of the Scottish teaching workforce in comparison to other sectors (Bell, 2011)). However, given rapid societal shifts, it is time to review traditional expectations that teaching jobs are "for life", and that teachers work five days a week.

Flexible working and part-time working are increasingly common in the UK[35]. In addition, the career expectations of the new generation are different to previous generations.

For the millennial generation, pay is not necessarily the most important feature of a job (Maxwell & Broadbridge, 2017; Ng, Schweitzer, & Lyons, 2010). Research indicates that millennials have realistic expectations of their initial graduate salaries, and will consider a less than ideal starting salary if the job presents other benefits (Maxwell & Broadbridge, 2017). This generation values enjoyment, work-life balance, opportunities for personal and professional growth, supportive work environments, and meaningful work experiences with social responsibility (Maxwell & Broadbridge, 2017; Ng et al., 2010).

A 2018 report on teacher workforce dynamics in England by National Foundation for Educational Research documents the challenges caused by increases in pupil numbers, an ageing workforce and high attrition rates[36]. This analysis notes that teachers are leaving the profession not necessarily to get higher rates of pay, but to increase job satisfaction and gain opportunities for part-time working. The report recommends that " The Government and stakeholders in the secondary sector need to look urgently at identifying ways to accommodate more and better part-time working in secondary schools"(p6) on the grounds that it could prevent teachers from leaving the profession and attract staff to return to teaching after a career break.

The Royal Society recommends in their recent review of computer science education in the UK that "Industry and academia should support and encourage braided careers for staff who want to teach as well as work in another setting."[37] The Royal Society uses the term *braided careers to* describe individuals who pursue multiple career paths simultaneously, such as working part time in industry and part time in academia. We suggest that the term could be usefully extended to consider pathways where people choose to work in one career for a number of years before moving into another career, a theme which is explored in the study reported below.

METHODOLOGY

This study used mixed methods of a survey aimed at recent computing graduates, combined with focus groups of current computer science university students. Please note that the survey and focus groups were both conducted before the resolution to the pay dispute between the teaching unions

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[34] https://www.gov.scot/publications/summary-statistics-schools-scotland-8-2017-edition/pages/4/

[35] https://www.cipd.co.uk/knowledge/fundamentals/relations/flexible-working/factsheet

[36] https://www.nfer.ac.uk/media/3111/teacher_workforce_dynamics_in_england_final_report.pdf

[37] https://royalsociety.org/~/media/policy/projects/computing-education/computing-education-report.pdf

and the Scottish Government, and so the comments relating to pay do **not** refer to the revised salary scales after the 13% pay rise was agreed.

SURVEY

An online survey was distributed to computing professionals through the Skills Development Scotland employer network and personal industry connections in September 2018. The purpose of the survey was to follow up on findings from the literature review to answer the research questions: 1) Did these recent graduates consider teaching?; 2) What influenced their choices?; 3) Could they be persuaded to change their minds, and if so what factors are important? The intention was to get a broad overview of a range of individuals' views.

The cover email invited those who had graduated within the last five years to participate. Participation was incentivized by a prize draw for a £50 Amazon token. This yielded 56 responses (27% declined to give gender information, but of the rest 81% were male.) Many of the responses came from software developers at Amazon due to personal contacts of the researchers. This may have biased the sample towards more highly paid individuals which in turn may have affected their attitudes towards teacher salaries.

FOCUS GROUPS

Four one-hour focus groups were conducted with computer science or Informatics students (first to final year) in September and October 2018. Seventeen participants from Edinburgh, Edinburgh Napier, Heriot Watt and Glasgow Universities took part, and were rewarded with a £10 Amazon token for their time. The intention for this research was to explore computing students' views in some depth in order to gain insight into the sorts of solutions which might be appropriate. Questions included:

- Have you ever considered becoming a computing teacher? Why/why not?
- What (if anything) do you think you would like/dislike about being a computing teacher?
- How do you think being a computing teacher would compare to other jobs?
- What would your friends and family think if you said you wanted to be a teacher?

Some of the students at Heriot-Watt University were studying a final year course relating to computing education which required them to spend time teaching computing in local high schools. This gave them a more informed perspective on teaching than some of their peers which is of interest when exploring the possibility that exposing students to more information about teaching would be helpful for recruitment.

FINDINGS

SURVEY OF RECENT COMPUTER SCIENCE GRADUATES

The survey results indicated that 44% of the participants had considered CS teaching (Figure 3). Becoming a teacher was a possibility for 22% (see Figure 4), and 44% thought that computing was 'quite a good', 'good', or 'great' job option (Figure 5).

Q1. Have you ever considered teaching computing in schools as a career?

55%   21%   34%   22%   10%   12%   22%

■ I've never considered it   ■ It's crossed my mind   ■ I've given it some thought   ■ I've thought a lot about it   ■ I've fully considered it
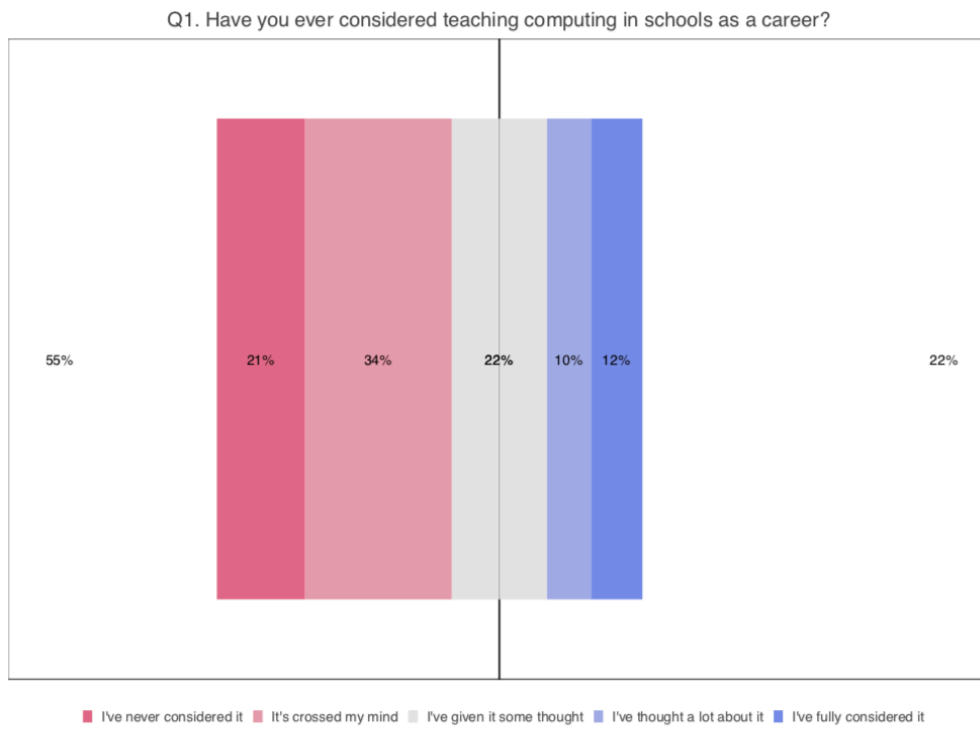
26 participants have thought about being computing teachers

Q2. How likely are you to pursue becoming a computing teacher?

78%   38%   40%   17%   3% 2%   5%

■ I intend to become a computing teacher   ■ It's a serious possibility   ■ It's a possibility   ■ It's unlikely   ■ I don't intend to become a computing teacher
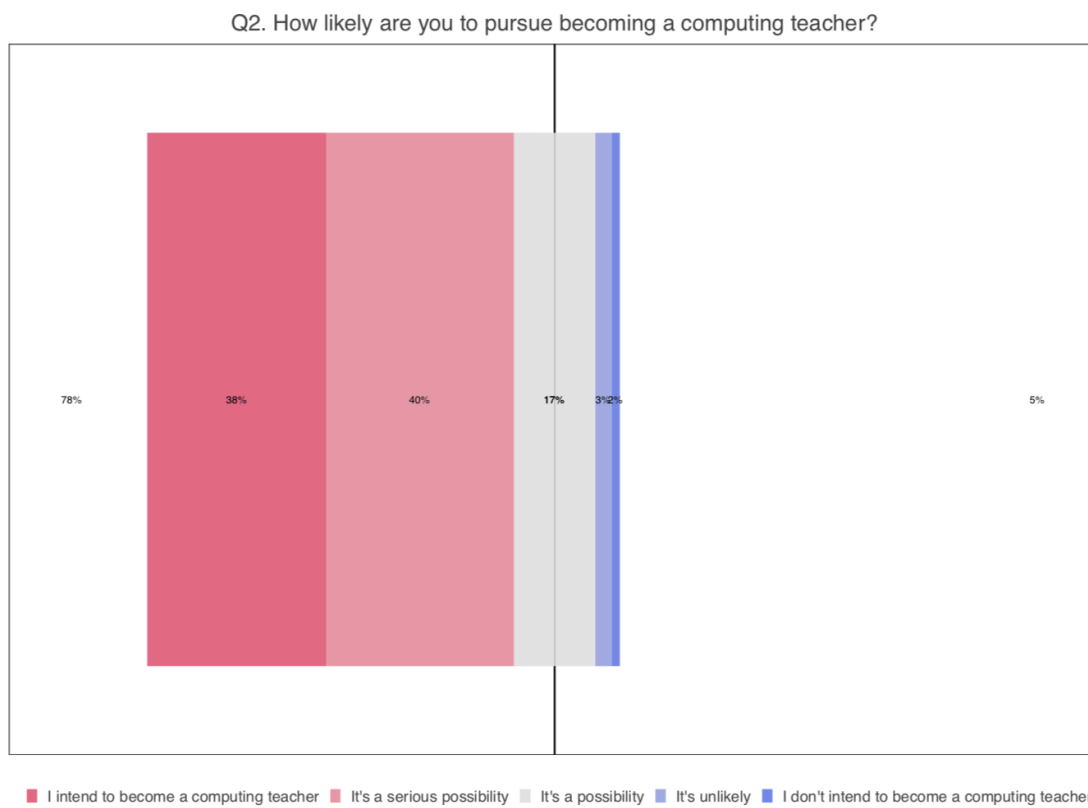
13 participants would possibly become computing teachers

Figure 4

Q7. To what extent would you consider computer science teaching to be a good job option?

| 56% | 12% | 44% | 23% | 15% | 6% | 21% |

■ It's a bad option ■ It's not a good option ■ It's quite a good option ■ It's a good option ■ It would be a great option

23 participants consider CS to be at least quite a good job option

Figure 5

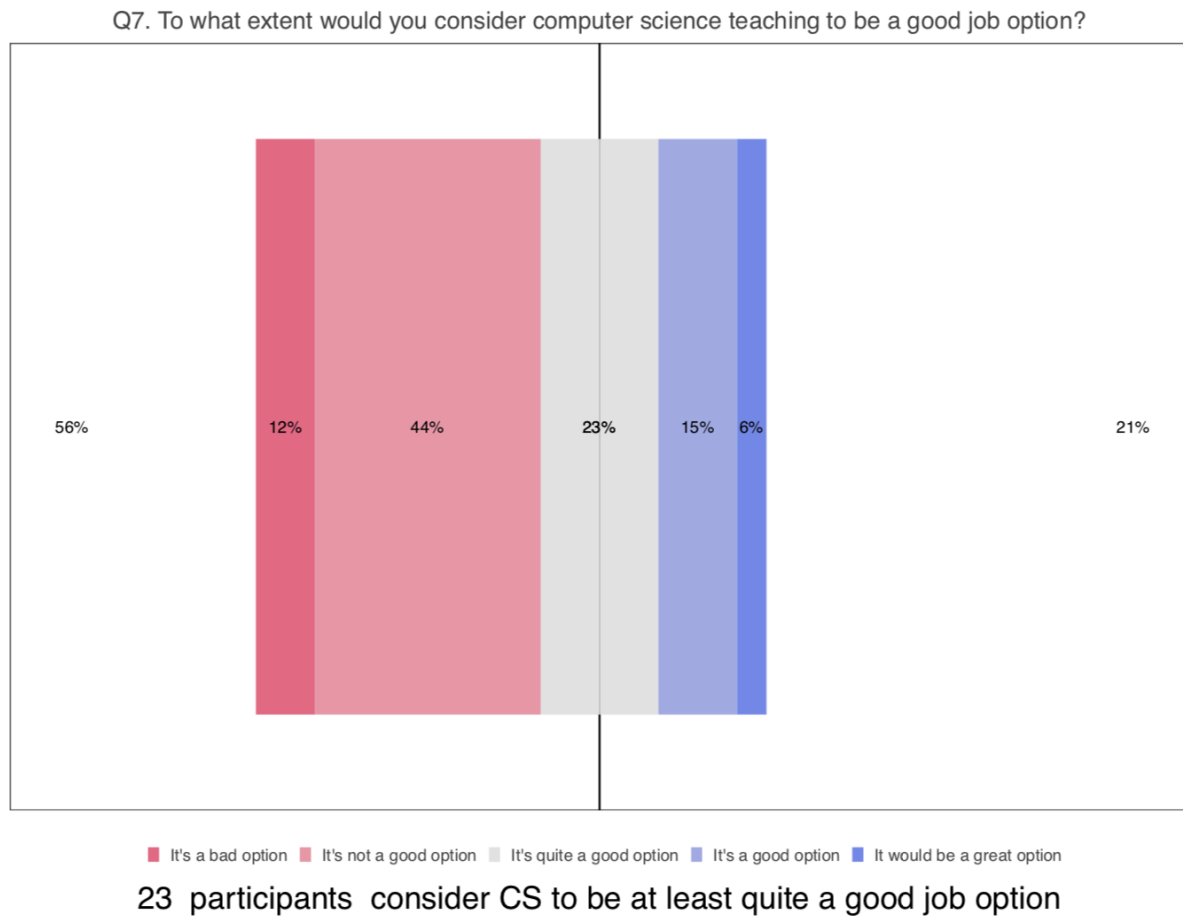Participants considered it important to use their computer science knowledge and skills in their career (Figure 6). 44% thought that computing teaching would use at least part of this knowledge, while 31% thought it would use most of their CS background (Figure 7).

Q5. How important is it that you use your computer science qualification and knowledge in your career?

8%   8%   12%   17%   29%   35%   81%

Not at all important   Not very important   Important   Crucial
Not important   Quite important   Very important
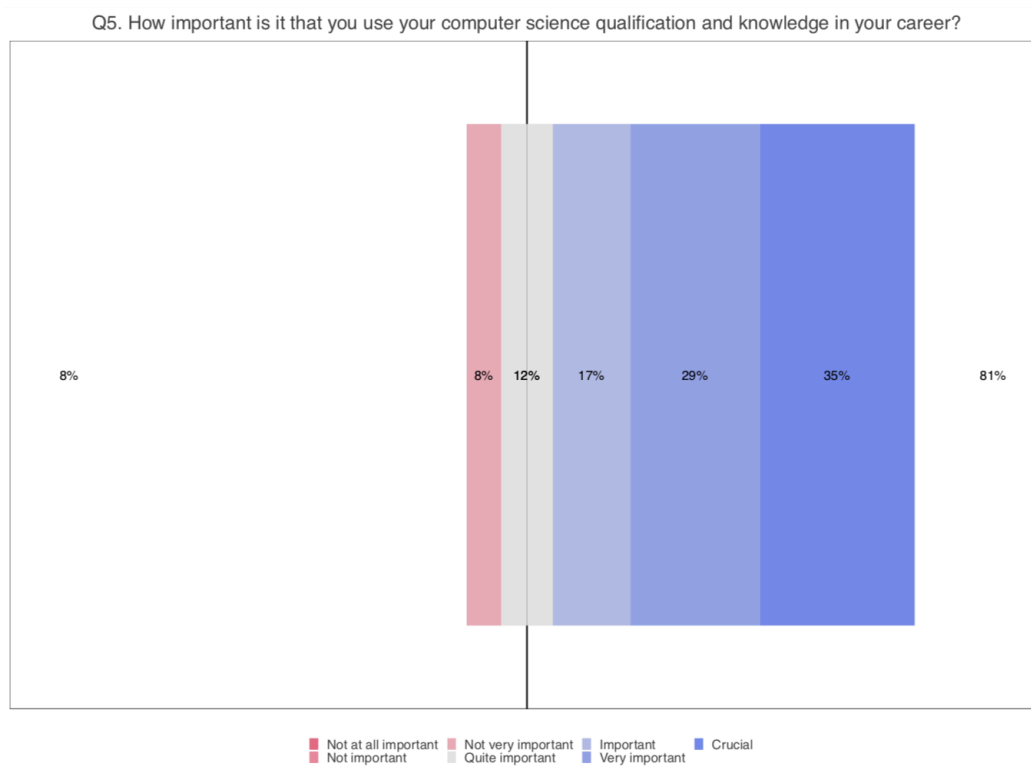
42 participants consider it important to use their computer science knowledge in their career

Figure 6

Q6. To what extent do you consider CS teaching to make full use of your CS qualifications and knowledge?

23%   2%   21%   46%   19%   12%   31%

■ It wouldn't use my CS knowledge at all   ■ It wouldn't use much of my CS knowledge   ▮ It would use part of my CS knowledge   ▮ It would use most of my CS knowledge   ▮ It would definitely use my CS knowledge
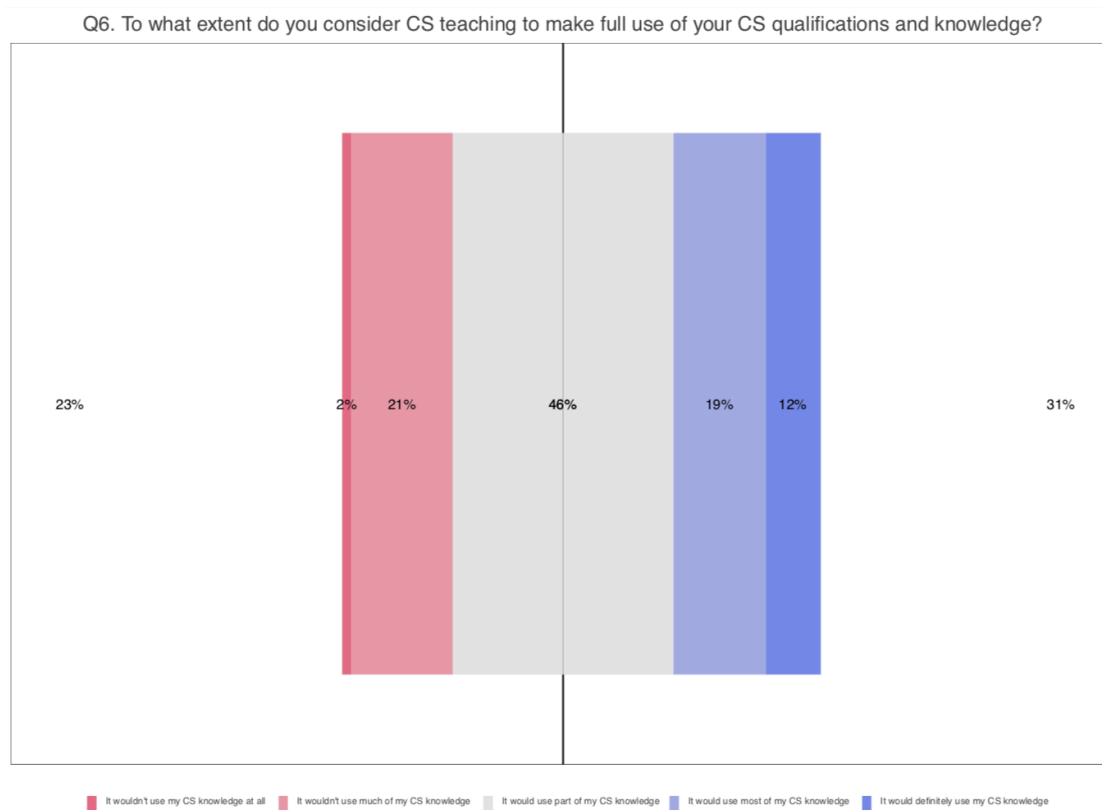
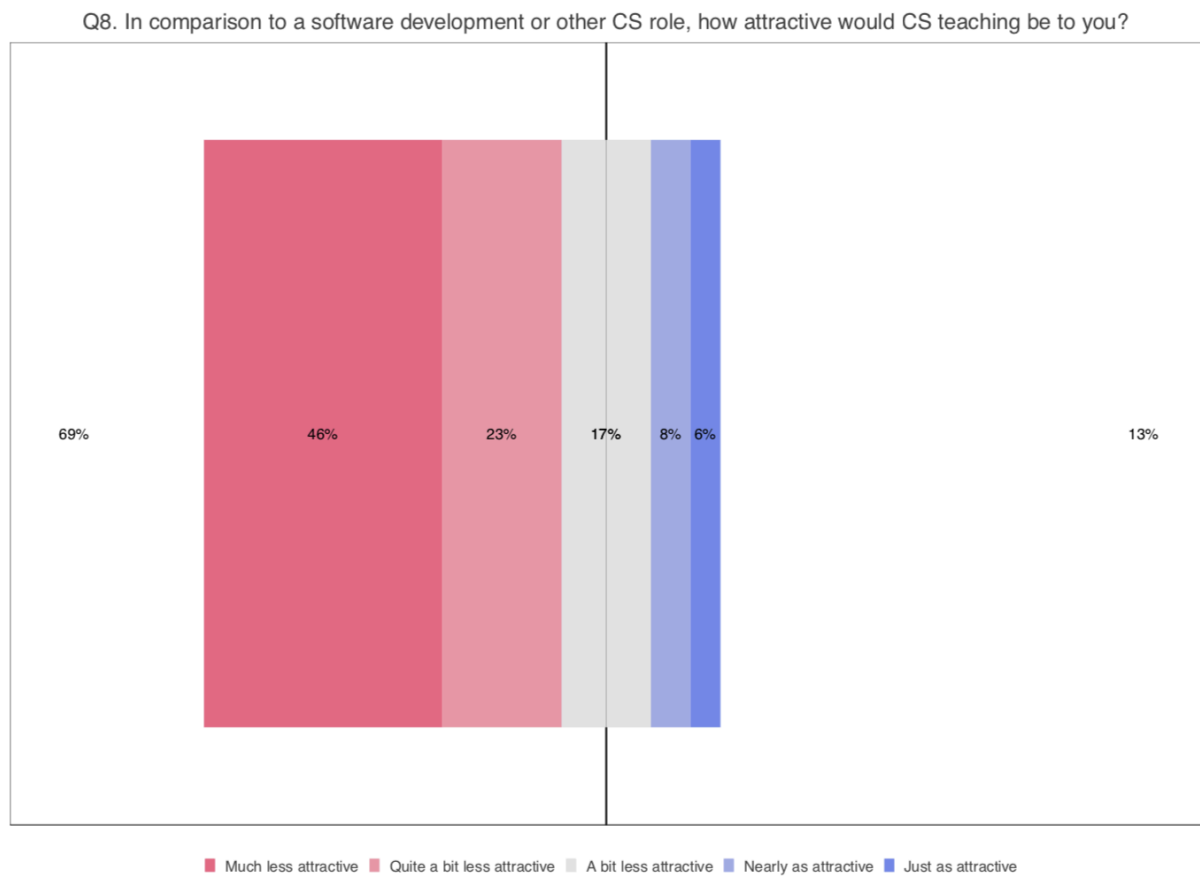16 participants think CS teaching makes use of most of their CS background
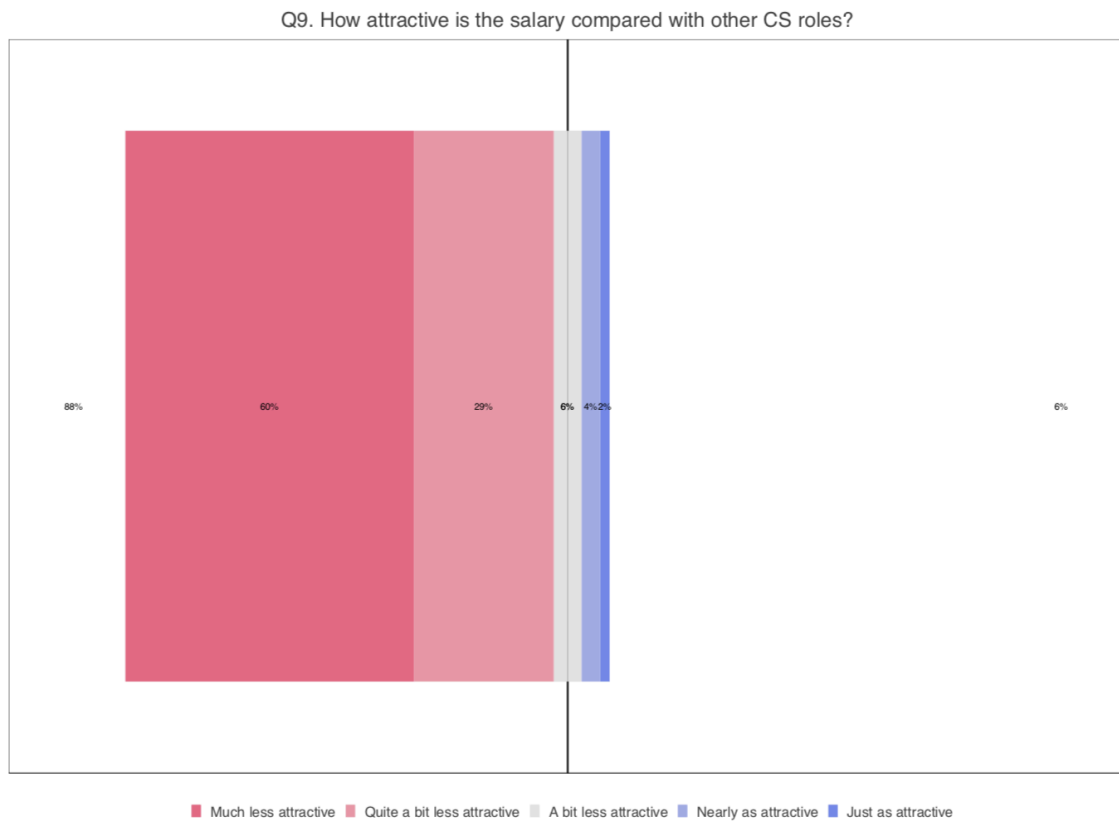
Figure 7

In comparison to other computer science roles, CS teaching was considered less attractive by 86% of participants (Figure 8). 88% of participants found the salary to be "quite a bit less" or "much less" attractive (Figure 9), and 48% found the other benefits "quite a bit" less or "much less" attractive (Figure 10).

Q8. In comparison to a software development or other CS role, how attractive would CS teaching be to you?

69%   46%   23%   17%   8%   6%   13%

■ Much less attractive   ■ Quite a bit less attractive   ■ A bit less attractive   ■ Nearly as attractive   ■ Just as attractive

7 participants consider CS teaching to be comparably attractive to other CS roles

Figure 8

Q9. How attractive is the salary compared with other CS roles?

88%   60%   29%   6% 4%2%   6%

■ Much less attractive ■ Quite a bit less attractive ■ A bit less attractive ■ Nearly as attractive ■ Just as attractive
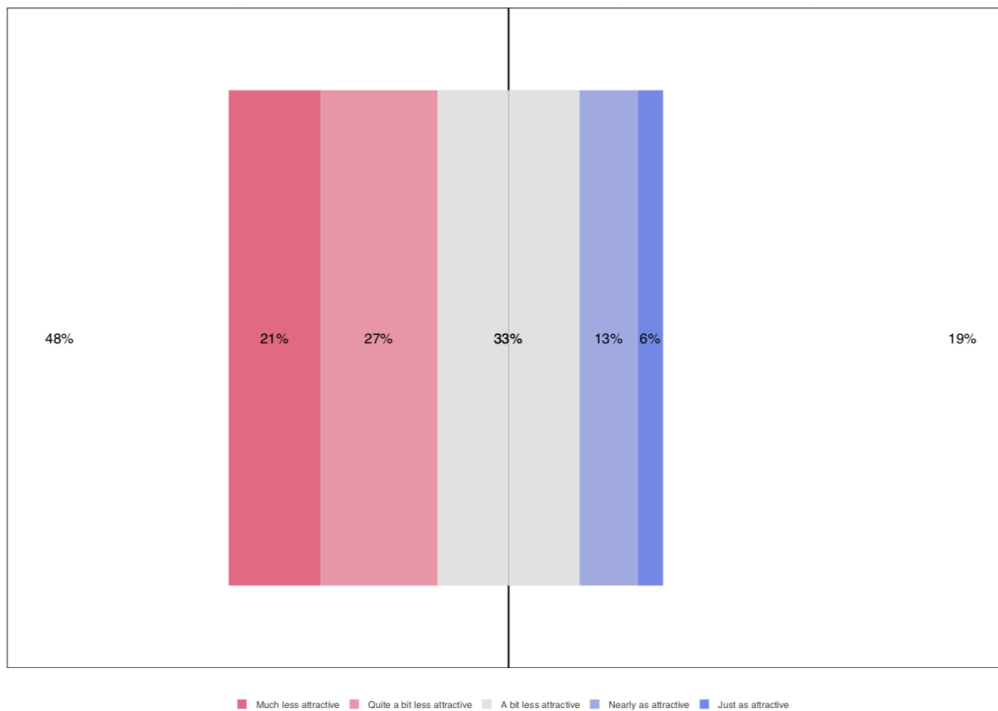
3 participants consider a teaching salary to be comparably attractive to other CS salaries

Figure 9

Q10. How attractive do you think the other benefits would be compared with other computer science roles?

48%   21%   27%   33%   13% 6%   19%

■ Much less attractive ■ Quite a bit less attractive ■ A bit less attractive ■ Nearly as attractive ■ Just as attractive
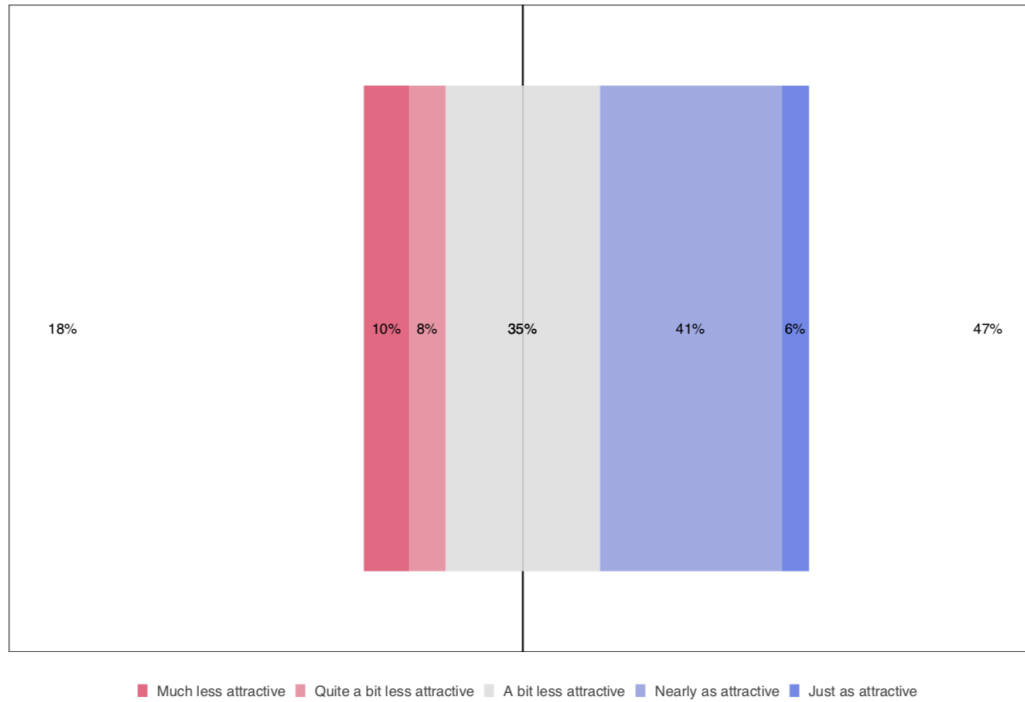
10 participants consider other teaching job benefits to be comparably attractive to other CS careers

Figure 10

When asked about non-traditional (or braided) careers, participants typically found them more attractive. Short-term posts (for 2-3 years) were found to be more attractive by 47% of participants (Figure 11) while 80% of people thought that part time working options would make teaching more attractive.

Q11. If computer science teaching was presented as something that you might do for a short time (2–3 years) before potentially embarking on another career, does that make it a more or less attractive job?

18%   10% 8%   35%   41%   6%   47%

■ Much less attractive ■ Quite a bit less attractive ■ A bit less attractive ■ Nearly as attractive ■ Just as attractive

23 participants find shorter teaching careers more attractive

Figure 11

Q12. If computer science teaching was presented as something that you could do part time while also working in the CS industry, does that make it a more or less attractive job?

8%   4% 4% 12%   51%   29%   80%

■ Much less attractive ■ Less attractive ■ No more or less attractive ■ More attractive ■ Far more attractive
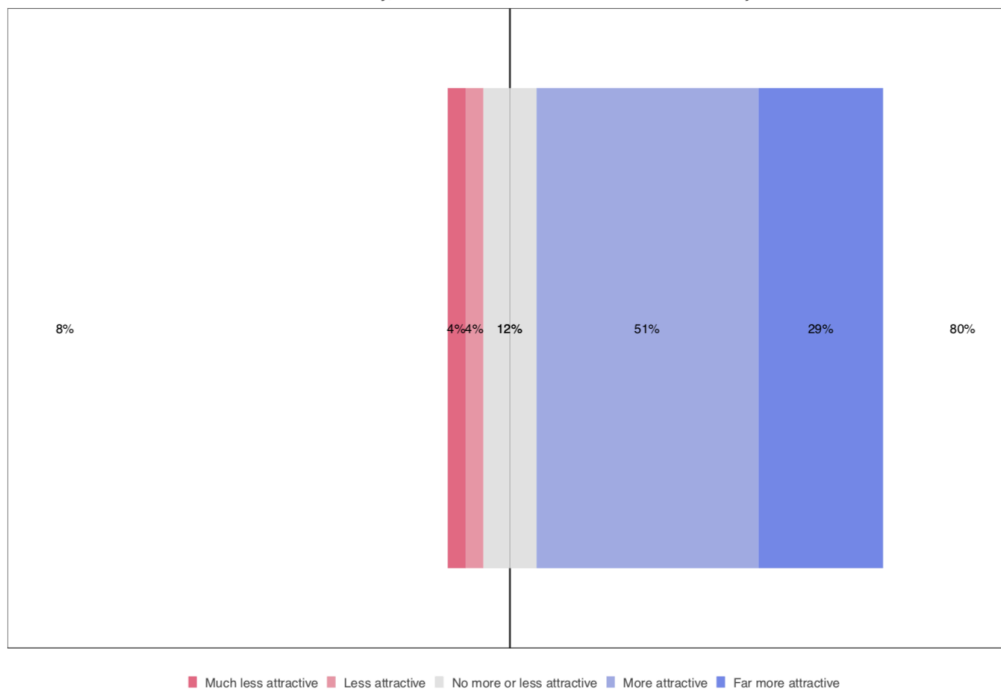
39 participants find part time teaching more attractive

Figure 12

The social value of teaching was considered to be the highest attraction by most participants, followed by the desire to help students, and wanting to make a social contribution (Figure 13). The most commonly occurring negative features were pay/rewards, lack of professional development, lack of future roles for career progression and the fear of losing current knowledge (Figure 14).
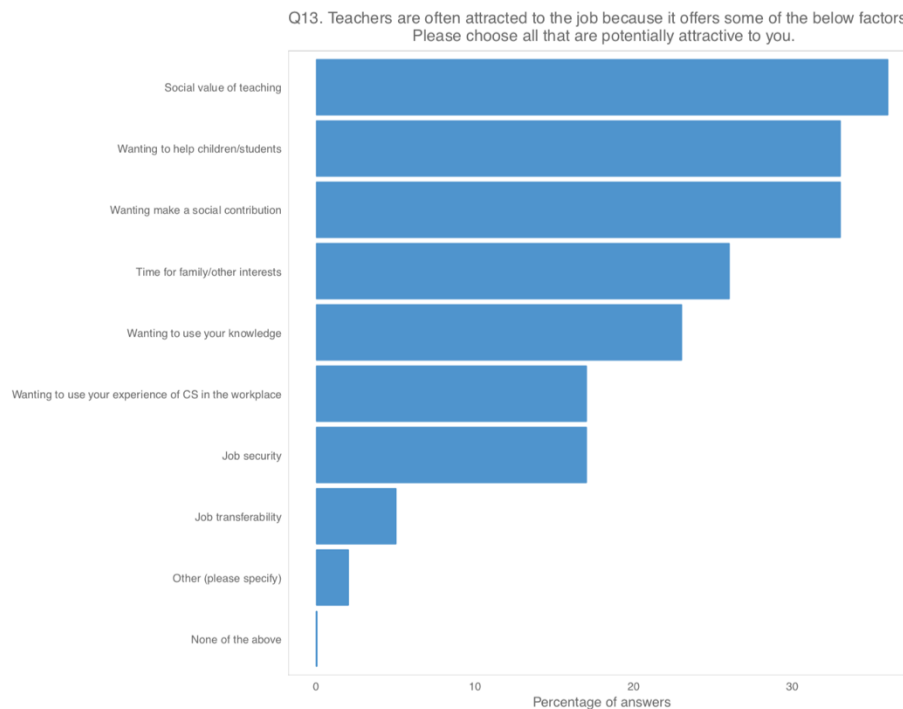

Q13. Teachers are often attracted to the job because it offers some of the below factors. Please choose all that are potentially attractive to you.

Figure 13 Attractive features of teaching

Q14. Sometimes people can be put off the idea of teaching by some of the below factors.
Please choose all that might put you off.
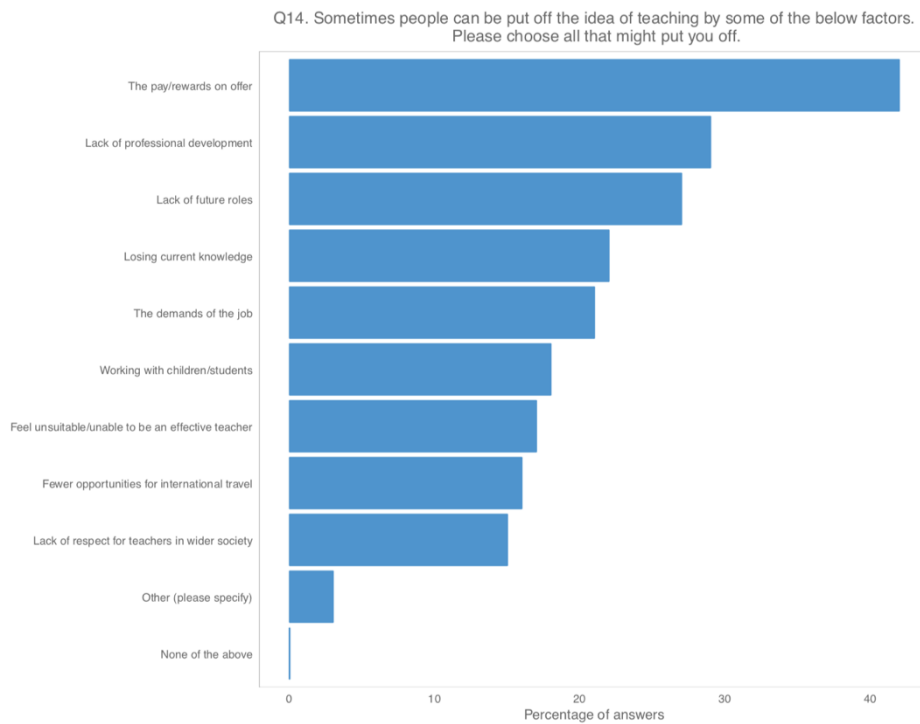
Figure 14. Potentially unattractive features of teaching

Q17. What exposure have you had to the idea of being a Computer Science teacher?
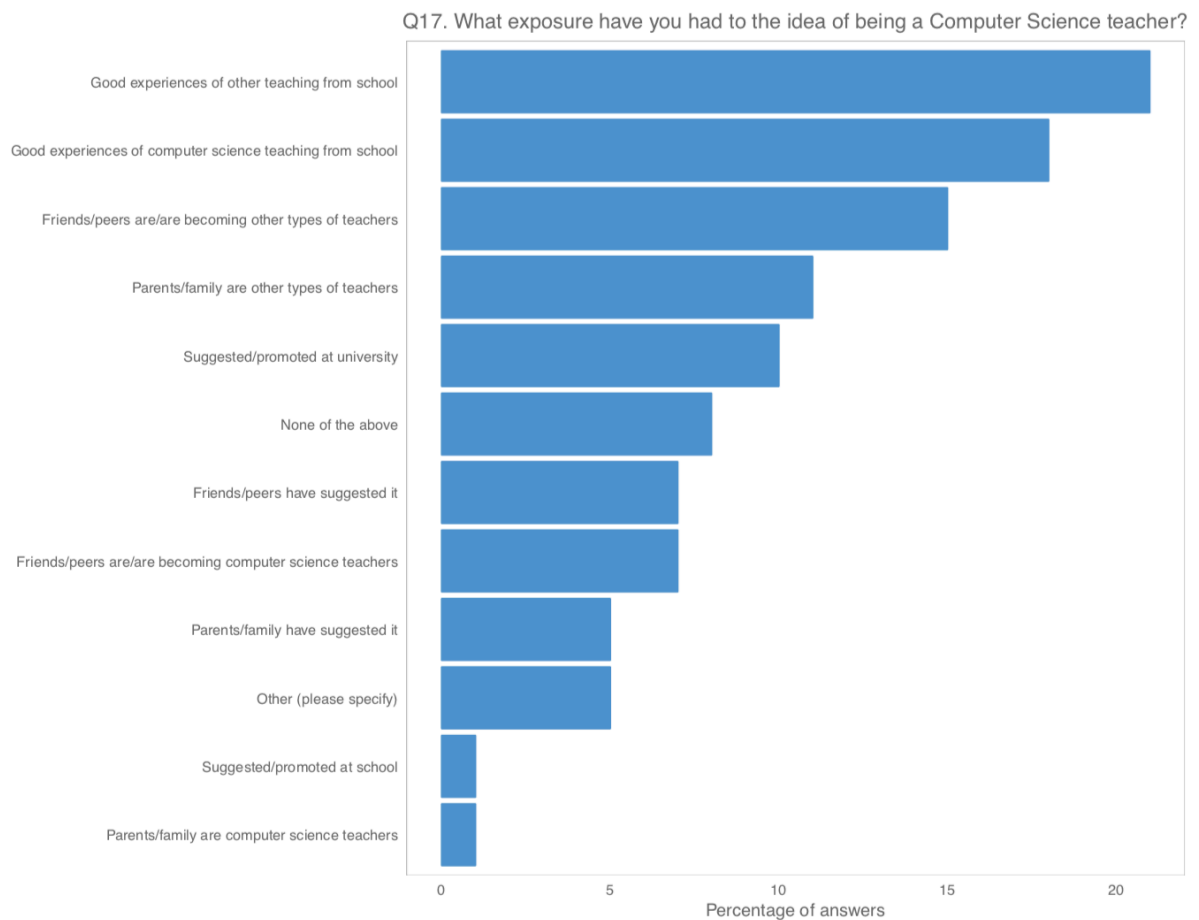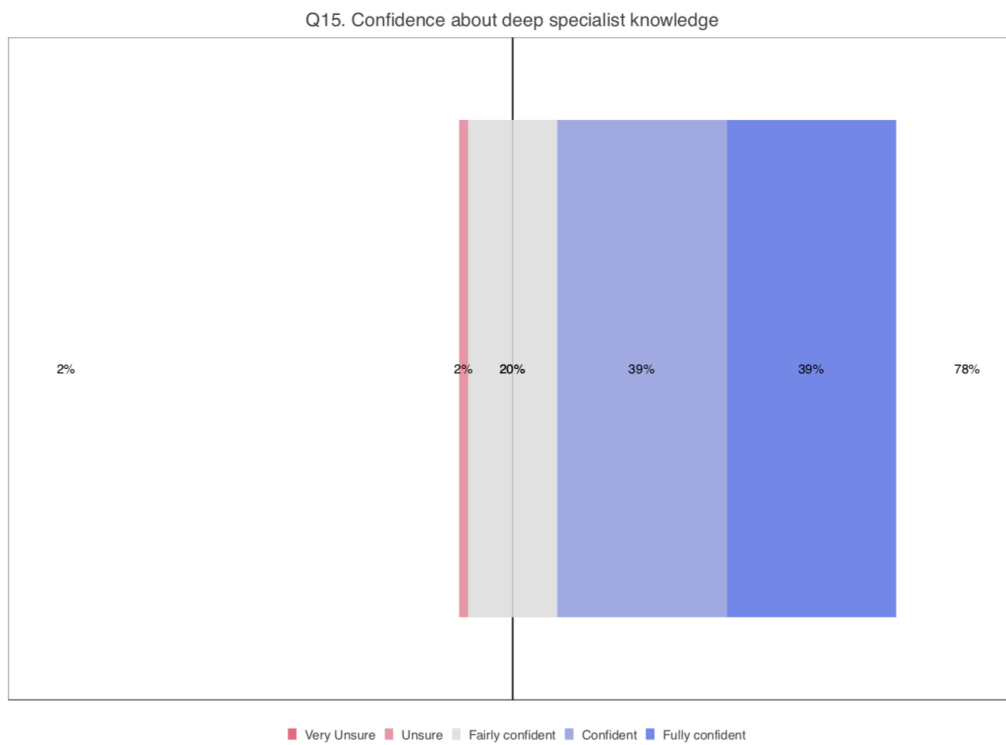
Figure 15. Exposure to the idea of teaching

Participants has most commonly been exposed to the idea of teaching as a career through good experiences of teaching at school, or because friends and family are teachers. It is worth noting that 16% of the applicants had never had exposure to the idea, and the idea of computer science teaching had been promoted to only 22% of participants at school or university (Figure 15).
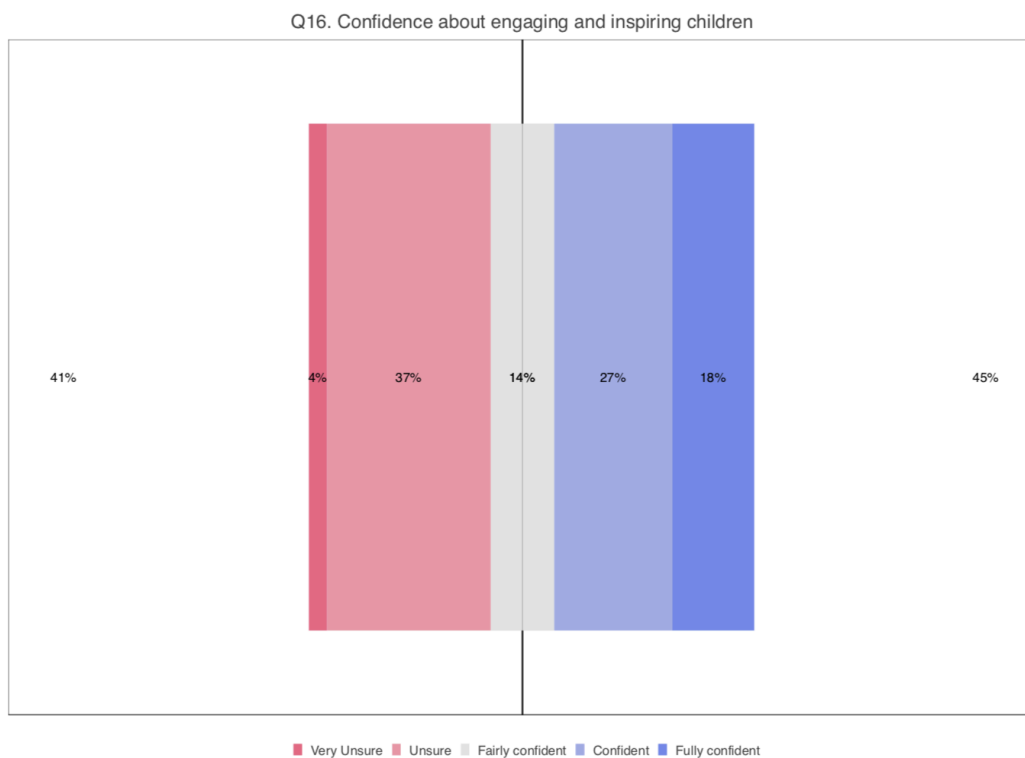
When asked about their confidence in their specialist knowledge or their ability to inspire and engage children, participants were considerably more confident in their specialist knowledge (

Figure 16); 41% were unsure about their ability to work with children (Figure 17).

Q15. Confidence about deep specialist knowledge

2%   2% 20%   39%   39%   78%

Very Unsure Unsure Fairly confident Confident Fully confident

38 participants are confident in their specialist knowledge

Figure 16

Q16. Confidence about engaging and inspiring children

41%   4%   37%   14%   27%   18%   45%

Very Unsure Unsure Fairly confident Confident Fully confident

22 participants are confident in engaging and inspiring children

Figure 17

Lastly, participants were asked for a free text response to the question: "What would you need to see, or what would convince you, to think more seriously about being a computer science teacher?". The 55 categorisable comments were categorised as shown in Figure 18.
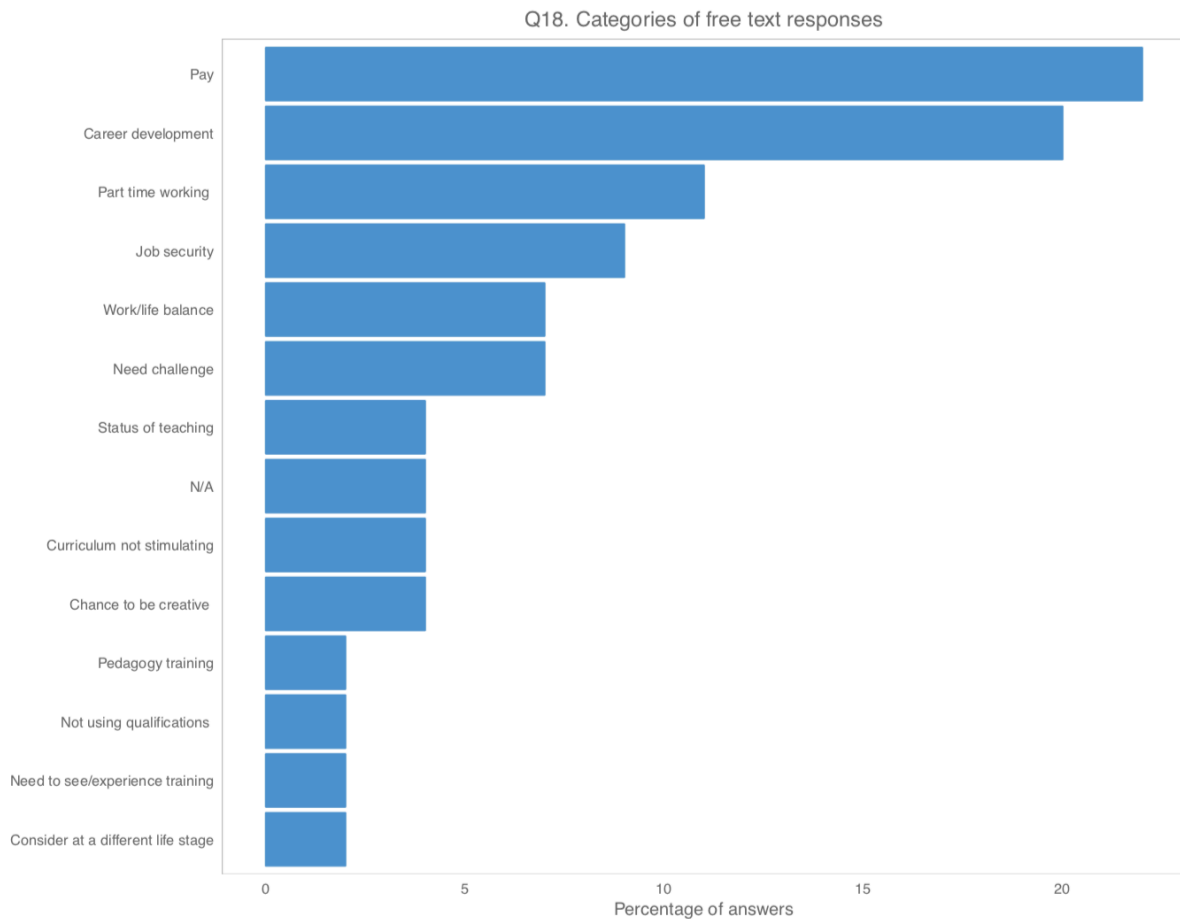

Figure 18

Pay and the perception that teaching does not offer opportunities for career development are most likely to prove a barrier for potential teachers – they would like to earn more, but would also need reassurance and examples of how their career can progress. The idea that teaching would not meet the desire for professional challenge was also raised. There is further affirmation for the idea of teaching part-time alongside another career. Participants were concerned about job security of teaching – some graduates see teaching as a less stable job. This was not an issue which has arisen in the literature but which may reflect the current news stories about teacher shortages and public sector budget cuts. Some participants were worried about workload and burnout which again is a topic in media coverage.

Category	Sample comments
Pay	A significant pay increase to compete with other computing roles in industry. (i.e. salary of £28,000 P.A. more)

	My primary worry would be compensation, which is very different from that of other technical roles.
	Vastly increased pay/benefits
Career development opportunities	There would need to be open plans for personal development, opportunities for growth
	I have systematically chosen a career path where I can learn and apply skills, not redistribute them. There are few things that could change this. I am happy to share knowledge in workshops, part-time teaching settings, show-and-tell, between colleagues and friends, etc.
	Detailed data on long-term prospects of teaching positions compared to development positions.
Part-time working	The option to do part time teaching as part of a full time software job. If that was possible (maybe one day a week) it would be very likely that I'd take that opportunity.
	Teaching as a way of giving back to the community beside my current work would convince me to do so.
	If it was offered part time, along with a software development job, thus helping me reap benefits of both.
Job security	Teaching (and, in general, public sector) jobs have less security (too many teachers or not enough budget for more teachers, it depends on the school/council) with significantly less compensation (half) and fewer benefits that an entire rethink around education job packages would be required.
Work-life balance	Opportunities for flexibility
	Massive changes to out of hours requirements (planning/marking)
	I'd need to see a few successive generations of teachers stay in the career without a high burn out rate to even consider it as an option.
The need for challenge	I would dearly miss having colleagues in my field to challenge me, and being exposed regularly to difficult problems that help me grow my abilities. I would also find it harder to keep up with new developments in my field. The salary cut is also a concern for me. I would like reassurance that I would have regular contact with peers in my field, and at least the option to work part-time as a developer.
	More freedom to innovate/experiment with teaching strategies as well as curriculum
	I perceive teaching as a repetitive job and a stagnation of knowledge, at least when teaching is the only activity. If it was a side activity I would probably enjoy it with mature students or children with a difficulty

Table 3. Sample answers to the question "What would you need to see, or what would convince you, to think more seriously about being a computer science teacher?"

FOCUS GROUPS WITH CURRENT COMPUTER SCIENCE STUDENTS

The focus groups were conducted at four different universities with students from a range of backgrounds studying courses with vocational or more theoretical flavours. Participants were on their first to final years of undergraduate degrees. Five students were women. This is 29% of the sample, which is higher than the average participation of women in computer science degrees nationally. Nine participants grew up in Scotland, two grew up in England and the rest were from other countries including India, Greece and Luxembourg. Two of the students came to their course as mature students after a career change, and two had originally studied other subjects at university. Six students had experience of teaching computing to children (five in Scottish classrooms through the Computing in the Classroom course at Heriot-Watt, and one internationally). The responses to questions were categorised using thematic analysis.

ATTRACTION TO COMPUTER SCIENCE

The students' descriptions of what attracted them to computer science included an intrinsic interest in "the mathematics and the logical thinking behind computer science"; a love of the technology itself; a recognition that technology skills are in "very in high demand right now" or "that's where the money is"; the decision to pursue a topic for which they had aptitude; and creative enjoyment of building new things.

VIEWS ABOUT TEACHING

Two of the students had definitely chosen to become teachers, with two more strongly considering it. An additional two students were interested in education, but preferred to pursue this through the development of educational software on the basis that their work would reach more learners.

When asked to consider the positive aspects of teaching, the students mentioned the fulfilment and pride in sharing knowledge and developing skills: "feeling satisfied at the end of the day that you have achieved something for the society and that you have taught somebody else how to do something". They spoke of the value of inspiring young people and helping them to develop: "you can't put words to how good it feels to inspire somebody". Some participants spoke of the opportunity to make a difference in the lives of young people by giving them educational opportunities – one student was particularly grateful for the help of his own teachers in encouraging him to apply for university.

Students were also asked to list what they would consider to be the negative aspects of teaching. There were concerns about the intrinsic nature of the job, as well as external factors including working environment, pay and rewards.

Several students raised a concern about repetition in what must be taught: "you would just be just churning out the same lessons…cause you're not really being challenged by just teaching the same thing over and over. You've gotta like find new ways to teach the thing but there's only so many ways you can teach a concept or teach how to do something before it gets like a bit repetitive, a bit boring".

Others felt they might be restricted by an out of date, narrowly focussed curriculum or by stringent assessment requirements: "you've gotta teach your set curriculum and I've seen teachers not be able to sort of spread their wings a bit and teach something off the curriculum because they don't have

the time.". The students valued having up to date knowledge of computing, and some thought they would be frustrated by "having to use outdated technology or methods".

Some students thought that they did not have the personal attributes which would be needed for teaching, such as patience, the ability to explain things well or a talent for public speaking. Some found the behaviour management aspect of the job, unappealing. "if it was an ideal world where you could go in and teach and kids wanted to learn, were there and eager it would be quite an interesting way to go but part of you become a parent almost, you have to be disciplining them and that doesn't appeal to me." However, views were mixed on the extent to which students wanted to engage with pastoral care. As one student put it, " the secondary role of becoming a social worker, a psychiatrist…" was off putting because "…you have to adopt the problems, be there for them but you can't get too involved because you can't interfere with their lives too much." In contrast, others relished the challenge of "developing a person".

Participants mentioned a range of off-putting structural aspects of the job. The main concerns related to over-work and stress. The students perceived that teachers would work long hours at home to prepare lessons and mark homework, in some cases because they saw this pattern in friends and family members who are teachers. They thought that the job would be stressful, partly because of long hours, but also because of behaviour management, the burden of responsibility, the demands of parents and administrative requirements. In addition, the students raised the issue of lack of career progression with the danger of teaching as a "dead end": "I feel once you undertake a teaching position it becomes harder to make your way back into industry. You become trapped". As a related point, there was a concern about becoming geographically trapped because of lack of transferability of teaching qualifications between countries. This contrasts with the software industry where there are many opportunities to work abroad.

PAY

During the focus groups, the interviewer asked the students to compare working in the software industry to teaching. If no-one mentioned pay (which happened in one focus group), the interviewer followed up with a specific question on pay. As soon as the topic came up, participants were shown a current teacher salary scale to inform their answers.

Participants' attitudes towards the teachers' pay were multi-faceted. Many of the students already had experience of working part-time or in the summer to fund their studies both in software and unrelated roles. The students had multiple points of comparison: the starting salaries which friends earn in the software industry; the rates of pay for their current intern or part-time roles; experiences from recruitment of other staff by their current employer; and media stories about the teachers' pay dispute. Many of the participants expected to earn considerably more in a graduate software role, particularly the Edinburgh and Glasgow university students. Some students strongly believed that teachers should be paid more.

Other students thought that the teacher salary was in line with what they might hope to earn, including one student who lived in the Borders who noted that salary expectations in rural areas were different. Geography played a part in attitudes to pay because of lower salaries in rural areas, and higher living costs in cities like Edinburgh and Glasgow. One student who had considered being a teacher found it financially impossible for him, while another who has already chosen teaching explained that:

"I know that by making that choice [to be a teacher] if I choose to have a family I'm gonna struggle to, to raise a family on my salary so like I hope my partner's got a decent salary as well and I know that I'm not gonna be able to afford to buy a house in Edinburgh and I've sorta had to accept these things".

Evidence from the focus groups suggests that improving teachers' pay would make it easier to recruit computing teachers. However, it is unlikely that the public sector would ever be able to match the higher end of the more ambitious students' expectations (e.g. £50, 000 starting salary).

INFLUENCE FROM FRIENDS AND FAMILY

Across the focus groups, the students thought that their friends and family would have a neutral or negative reaction if they were to become computing teachers. Some students said that their families would be supportive of whatever they chose to do, while others thought their family be have a "sense of disappointment" or even be "devastated". There were indications of different perspectives between generations: "the older people [in my family] seemed to think 'oh yeah it's a respectable job, steady career', but then friends are like 'pfft, I'll see ye later I'm away to make money'". One student noted that "My grandmother's actually encouraging me to go for teaching as a fallback". With respect to the views of friends, one student said "I think in our course there might be an unspoken feeling of you've taken the easier path" and another commented that friends would "view it as me failing. They'd kind of assume that I'd failed to get into a company or something and it wouldn't be a first choice".

There was a consistent view across the focus groups that while the students personally respected and valued good teaching, they thought that society and their social circles do not.

INFLUENCE FROM EXPERIENCES WITH TEACHERS

Participants, in each of the focus groups, who had been taught by teachers who seemed unmotivated or incompetent did not want to become that way themselves. The topic of teacher workload and working conditions leading to cynicism and burn out was often discussed. "I think unfortunately there are quite a lot of teachers that just don't really care that much or they've been kind of jaded by the system". A participant commented that "I don't think a lot of people go into teaching wanting to be a bad teacher" but he thought pressures of the job including curriculum restrictions and assessment requirements could cause poor teaching. Another student mentioned that some teachers "devalued the profession" because they appeared to put in little effort to help pupils learn. This student also mentioned how much she valued the teachers who inspired her because "make a lasting impression on you and you do have respect for them".

A participant wanted to avoid becoming a teacher as a second choice because it would have a "negative impact on who you're teaching… they can feel that this isn't what you want to do and I don't think that's fair on the student or, or yourself."

One participant noted that working in an environment with unmotivated teacher colleagues would be off-putting.

BRAIDED CAREERS

The interviewer asked the participants about their views on either working part time as a teacher, or spending a few years in teaching as part of a broader career path. For some this was an attractive option:

"That's been my ideal and I've been thinking about trying to do that. That's always been my kind of plan, I was gonna go train as a teacher, became a teacher, wait until I was fully qualified and then start looking to pile back the work and become a part time teacher and work two days a week in another company."

The student noted this would work best for educational software companies because there would be a "kinda positive feedback loop of … each one is useful for the other".

Some participants, although generally positive, were concerned about how the part-time option would work in practice with two demanding jobs: "I think it would be real challenging and difficult cause being dedicated to two jobs in the same time, especially one of them being a teacher is quite difficult as you have to spend extra time…preparing class". Students were wary that either the software employer or the local authority would put pressure on part-time workers to do more work.

One student mentioned the idea of a sign on contract for those who wanted to be teachers for a short period after graduation "may be upping or given a sign on bonus, but you're locked in for three years as being a teacher and then the incentives start to kick in". The students spent less time talking about the idea of coming back to teaching later in their careers. One mentioned that he would consider it as a way to give something back, but others thought it would be difficult to take a salary cut.

SUGGESTIONS FOR ATTRACTING MORE COMPUTING TEACHERS

A common theme across the focus groups was that the students wanted more information about teaching careers to enable them to seriously consider it. It would appear that the information can be found with some effort ("I had to ask a friend because Google wasn't helping me"), but it is not actively promoted to students as information about other careers would be. Students pointed out that big technology employers are often invited to give careers talks at university but "but no-one ever hears about … teaching".

The Computing in the Classroom course at Heriot-Watt University was considered to be a useful source of information, as was the PGDE open day event for students at University of Glasgow. One student suggested it would be useful to have a "trip advisor for teaching careers" with a breakdown of statistical information for easy comparison. Students wanted easy access to information about:

- Next steps to becoming a teacher – what qualifications are required and the application process
- The current demand for computing teachers by region
- Salary scales
- Job prospects and career progression
- Work hours and holiday arrangements
- Benefits
- How placements and probation allocation decisions are made
- Opportunities to work abroad and transferability of qualifications

- Views about job satisfaction and happiness from current teachers
- Average work load – how much additional time spent working at home by subject specialism
- Additional opportunities to help out in the community

It is worth bearing in mind that this information will be particularly useful for the many computing students in Scotland did not attend school in the UK and have no knowledge of how the system works.

One student suggested a scheme to fund people to study for an MSc or PhD in computing while working part-time as a teacher in order to "… allow them to become a better teacher because they would have more knowledge. And then potentially it would be attractive to people because in theory you could go, become a teacher, teach for a number of years, say like six years or whatever, achieve a PhD at the end of it".

DISCUSSION OF FINDINGS

Reflection on the current state of computing teaching in Scotland, and findings from the literature review, survey and focus groups has led us to the following insights.

Firstly, it is possible to successfully tackle the current shortage of computing teachers in Scotland. There are healthy numbers of computer science students graduating in Scotland each year (in the order of 5,000 per year), and last year Scottish Government set the target of recruiting 55 student computing teachers. We need only around 1% of computing students to become teachers in order to improve the situation.

Secondly, there is considerable room for improvement in attempting to persuade computer science students to become teachers. Only 22% of the survey participants had been exposed to the idea of being a teacher at school or university; this was consistent with the focus group students' experiences. Those who had tried to find basic information about how to apply, or working conditions had difficulty in finding it.

Thirdly, the salary scales for teachers and IT professionals overlap. There are wide salary variations within the IT industry, and geographical variations in cost of living which make this issue more complex than it might at first seem. It is true that teaching would be more attractive to more computer science students if it was paid better, but it is not true that all computer science graduates in Scotland will end up in much better paid jobs than computing teachers.

Fourthly, we need to consider other aspects of teaching which are important to our graduates, beyond pay. The students and graduates are committed to lifelong learning and personal growth. They want to stay up to date with their technical knowledge and apply those skills in their jobs. They want to be challenged every day. Evidence from prior work indicates that lack of professional learning has a detrimental effect on teacher retention in the country -the 2017 report on teacher workforce planning from the GTCS found from a survey of lapsed teachers that insufficient support for professional learning and career develop was one reason why teachers in general leave the profession. Working to improve professional learning opportunities for computing teachers would have the benefits of raising job satisfaction for current teachers, enhancing experiences for learners and making it easier to persuade graduates to become teachers.

Lastly, our participants value the work of teachers and firmly believe that is important to society. 44% of survey participants thought being a computing teacher was a quite a good, good, or great job option.

PROPOSED SOLUTIONS

SHORT TERM: IMPROVING COMMUNICATION

We recommend that **a short term project to promote teaching careers to computer science undergraduates should be a priority**. Both recent graduates and current students reported that they did not typically receive information or persuasion to become teachers in the course of their studies whereas they often got information about careers in the technology industry.

While there is a general campaign to encourage people into the teaching profession, and an existing website with information about teaching careers in Scotland, these either have not been effective enough for computer science students or it is too early for effects to be seen in these cohorts. We recommend that the **universities (through SICSA Education) work together to identify opportunities to promote teaching to their students** e.g. during careers fairs within computing departments, or inviting current enthusiastic teachers to give careers talks, or informal Q&A sessions. In addition, **promotional materials such as a website, video and leaflets should be developed with computer science students specifically in mind**. Students should have access to the facts and figures which participants requested during the focus groups, as well as stories from teachers about the satisfaction which the job can bring.

MEDIUM TO LONG TERM: FLEXIBLE ROUTES TO TEACHING

EASY ROUTES INTO THE CLASSROOM

In the survey, recent graduates expressed a lack of confidence in their ability to inspire and engage children. This was also a theme in the focus groups, where some students wondered whether they had the skills or personal qualities to be a teacher. This suggests that low-risk opportunities for computing students (or professionals) to try working with children in schools would be beneficial. While many of those who try out classroom teaching will decide that this career choice is not for them, they will have the information to make an early informed decision without wasting money or time starting a PGDE qualification which they do not complete. Classroom experience may also inspire some computing students to consider a teaching career who may not have seriously considered it before. The biggest benefit of easy routes into the classroom, however, is that computer science students and professionals have skills which are greatly in demand in schools. They have up to date technical and fundamental theoretical knowledge of the discipline which are valuable to teachers and learners in our schools today, regardless of what their career choices might be tomorrow.

Informatics Europe has recommended against bootstrapping the improvement of computing education in schools through co-teaching by industry professionals without additional training. While we agree with Informatics Europe that in ideal world the subject should be taught by those with both subject expertise and specialist pedagogical knowledge, we believe this requires further consideration because of the sustained difficulty of recruiting and retaining specialist computing teachers. Perfect should not be the enemy of good; we should be open to possible routes which will

lead to higher levels of computing education in schools in the long run. From a pragmatic perspective, there are already established programmes by which IT industry professionals contribute to classrooms so our focus should be on maximising the educational effectiveness of these.

There is currently a patchwork of opportunities for computer science students and professionals to share their knowledge with young people, including the Computing in the Classroom courses from various universities; schemes in which companies organise school visits, and extra-curricular clubs such as Coder Dojo. While these initiatives are beneficial, they tend to be of limited geographical scope and do not ensure that all young people in Scotland have access to computer science education. Furthermore, they vary in the extent to which they relate to the curriculum. It would be of benefit therefore to establish a project to **consolidate opportunities for computing experts (students and professionals) to help in computing classrooms,** to **match individuals with a school which needs assistance,** to **provide training and guidance on the curriculum and the classroom environment**, and to **support host teachers** in working effectively with the computing expert.

To prevent volunteer burnout and maximise the sustainability of easy routes into the classroom, it is important that individuals should be rewarded for their time. There should be different ways of achieving this. We recommend that the following options should be considered to be offered at the same time:

- **Expertise for study credit**. University students (in the final UG or MSc year) could elect to study a course such as the Computing in the Classroom in which they receive academic guidance and credit points towards their final degree for assisting in school classrooms.
- **Expertise for pay**. University students (at any stage of study, including PhD) or other individuals with computer science experience could be paid to assist teachers in school classrooms on a part-time basis. The British Council runs a similar scheme for language assistants[38] in which native speakers of languages such as French, German, Spanish or Mandarin get paid £914.50 for a standard 12 hours per week to help a qualified language teacher in the classroom.
- **Expertise for recognition**. Some individuals may not require pay for their time, and may not have the opportunity to study a relevant course at their university. There should still be an option to recognise their contribution to education, perhaps in the form of an open badge or a scheme such as the Edinburgh Award[39] for extra-curricular community building work.

	Benefits	Drawbacks	Next steps	Notes
Expertise for study credit	Student gets university academic mentoring with learning about	Admin overhead for university staff in organising host school	Work with SICSA Education to discover how many universities	Universities which already run this course tend interview students before accepting them to

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[38] https://schoolsonline.britishcouncil.org/about-programmes/language-assistants

[39] https://www.ed.ac.uk/edinburgh-award

			already run such a course, how effective they are, coverage of schools, current challenges and opportunities to scale wider.	ensure they will be suited to the classroom
	pedagogy and policy Student's efforts rewarded as part of studies Ongoing link between schools and universities			
Expertise for pay	Students have an opportunity to work in a high quality job related to their studies which is valuable to the community	Cost for paying experts	Research how the British Council (or other similar organisations) administer the scheme, estimate costs and consult with stakeholders before investigating potential funding routes	There are potential issues relating to the teaching unions which should be considered
Expertise for recognition	Volunteers receive formal recognition of their efforts – useful for cv or to document CSR work for employer	Admin overhead for running a badge or other scheme	Research appropriate open badge models and equivalent mechanisms. Consult stakeholders about their opinions	

Learners will benefit from up to date CS knowledge and inspiring interactions with role models. Teachers will benefit from support in the classroom and refreshing of their knowledge.

Table 4. Rewarding computer science experts' contributions to the classroom

FLEXIBLE TEACHER EDUCATION

We recommend that stakeholders work together to find agile ways to welcome potential computing teachers into the profession. **The existing expertise of recent computer science graduates or career changers should be recognised, and there should be flexibility about accreditation of prior learning.** For example, the GTCS requires PGDE computing students to have a qualification in Higher English (C or above) or equivalent. There is some indication from the current Computing in the Classroom cohorts that students who wanted to become computing teachers were not accepted onto

PGDE programmes because they did not have a formal qualification in English. More flexible demonstrations of English competency should be considered such as a university dissertation or a portfolio of professional reports. The required maths qualifications are perhaps less likely to be a barrier to recent graduates because maths is usually an entry requirement for an undergraduate CS degree, but it is possible that an otherwise well qualified career changer could have never studied for a qualification in maths but instead gained the required knowledge during their technical career.

There is some indication that current computing students who wish to become teachers may have less experience of working with children than other applicants for ITE courses. We recommend that in the future **prior documented experience** from Computing in the Classroom courses, open badges or paid employment as a computing expert in a classroom **should be used during the selection process to ITE programmes**, and potentially could be used to expedite progress through the degree (for example by replacing an introductory course).

To support career changers, the **universities should offer more flexible study options, including blended, online and part-time programmes**. The GTCS has called for Initial Teacher Education Institutions to think more creatively about flexible courses for student teachers, which has resulted in eleven new programmes supported by the GTCS[40]. The design of flexible courses for computing teachers will require careful consideration of how to balance university study with classroom experience, with possible employment commitments during part-time delivery.

BRAIDED CAREERS

We recommend that local authorities who employ computing teachers and IT employers work together to consider how braided careers could benefit the organisations, employees and learners. For example:

- Companies and local authorities could create joint jobs, where employees could simultaneously work part time as a teacher and part time as a software developer;
- Companies could part sponsor (or even just make deferred job offers) to promising graduates who want to spend 2-3 years in the classroom before moving to industry;
- Companies could offer internship or shadowing roles to teachers who want to keep their technical skills up to date;
- ITE universities and local authorities could work together to make it easier for later career industry professionals (or retired individuals) to transition into teaching.

Such schemes would require changes in attitudes about teaching careers. As discussed previously, there is currently a low proportion of part-time teachers and that there is a low rate of transfer in or out of the Scottish teaching profession. This is in contrast to overall changes to the labour market in the UK where demand for high quality, flexible work is growing. Participants in this study were attracted by braided career options but correctly noted that the employee could potentially be pressured by working for two employers. It is important that any schemes developed to support braided careers should attend to the care co-ordination and communication between the employers.

CONCLUSIONS

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40 http://www.parliament.scot/S5_Education/Inquiries/20170427GTCS-SubmissionTeacherWorkforce.pdf

Meeting the demand for computing teachers in Scotland is within our reach, given the volume and quality of computer science graduates which the country produces. This report recommends that national stakeholders– including government agencies, GTCS, universities, IT employers, and learned/professional societies - take joint responsibility for working on both immediate and sustainable approaches to ensure that in the future all of our children and young people learn computer science from knowledgeable, engaging and inspiring teachers.

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APPENDICES

APPENDIX 1: SURVEY QUESTIONS

Q1. Have you ever considered teaching computing in schools as a career?

Q2. How likely are you to pursue becoming a computing teacher?

Q3. Have you ever considered teaching another subject as a career?

Q4. Have you ever considered teaching¬†in a primary school as a career?

Q5. How important is it that you use your computer science qualification and knowledge in your career?

Q6. To what extent do you consider computer science teaching to be¬†a job that makes full use of your computer science qualifications and knowledge?

Q7. To what extent would you consider computer science teaching to be a good job option?

Q8. In comparison to a software development or other computer science role, how attractive would computer science teaching be to you?

Q9. How attractive do you think the salary would be compared with other computer science roles?

Q10. How attractive do you think the other benefits would be compared with other computer science roles?

Q11. If computer science teaching was presented as something that you might do for a short time (2-3 years, say) before potentially embarking on another career, does that make it a more or less attractive job?

Q12. If computer science teaching was presented as something that you could do part time while also working in the computer science industry, does that make it a more or less attractive job?

Q13. Teachers are often attracted to the job because it offers some of the below factors.
Please choose¬†all that¬†are potentially attractive to you.

Answer Choices

Job security

Time for family/other interests

Job transferability

Wanting to use your knowledge

Wanting to use your experience of using computer science in the workplace

Wanting make a social contribution

Wanting to help children/students

Social value of teaching

None of the above

Q14. Sometimes people can be put off the idea of teaching by some of the below factors. Please choose¬†all that might put you off.

Answer Choices

Working with children/students

The demands of the job

The pay/rewards on offer

Losing current knowledge

Lack of professional development

Lack of future roles

Feel unsuitable/unable to be an effective teacher

Fewer opportunities for international travel

Lack of respect for teachers in wider society

None of the above

Other (please specify)

Q14. Sometimes people can be put off the idea of teaching by some of the below factors. Please choose¬†all that might put you off.

Answer Choices

Working with children/students

The demands of the job

The pay/rewards on offer

Losing current knowledge

Lack of professional development

Lack of future roles

Feel unsuitable/unable to be an effective teacher

Fewer opportunities for international travel

Lack of respect for teachers in wider society

None of the above

Other (please specify)

Science and technology teachers – including computer science teachers – need a deep, specialist knowledge. And, like any teacher, they need to be able to impart that to children in an engaging and inspiring way. Can you rate your personal confidence for these two aspects of the job?

Q16.   Engaging and   Inspiring Children

Answer Choices

Fully Confident

Confident

Fairly Confident

Unsure

Very Unsure

Q17. What exposure have you had to the idea of being a Computer Science teacher? (Tick all that apply)

Answer Choices

Parents/family are computer science teachers

Parents/family are other types of teachers

Parents/family have suggested it

Friends/peers are/are becoming computer science teachers

Friends/peers are/are becoming other types of teachers

Friends/peers have suggested it

Good experiences of computer science teaching from school

Good experiences of other teaching from school

Suggested/promoted at school

Suggested/promoted at university

None of the above

Other (please specify)

Q18. What would you need to see, or what would convince you, to think more seriously about being a computer science teacher?

Q19. Do you have any other comments about the prospect of becoming a computer science teacher?

Demographic questions: age, gender, location and year of graduation.

APPENDIX 2: FOCUS GROUP QUESTIONS

1. Think back to the time when you decided you wanted to study CS. When was this? What drew you to computer science?
2. Have you ever considered becoming a computing teacher? Why/why not?
3. What (if anything) do you think you would like about being a computing teacher?
4. What (if anything) do you think you would dislike about being a computing teacher?
5. How do you think being a computing teacher would compare to other jobs?

     (If pay mentioned, ask what they think teachers earn)

6. What would your friends and family think if you said you wanted to be a teacher?
7. What information would help you to make a decision about whether to become a computing teacher?
8. If you were in government, what would you do to encourage more people to become computing teachers?