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Should we be concerned about who is studying computing in schools?

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Abstract

In the aftermath of national lockdowns, the need for digital competency has been made clearer than ever. However, millions of adults in the UK are said to lack digital skills, potentially causing many young people to miss out on the vast opportunities and career prospects afforded through a computing education. In this short chapter, we question whether we should be concerned about who is studying computing in schools. We begin with an overview of the numbers and social demographics of English students choosing Computer Science (CS) as a GCSE option. Of particular note is the underrepresentation of girls, who were amongst the least represented in CS compared to other GCSE subjects in 2020. We draw on various theories and explanations to explore possible reasons for unequal patterns of participation in CS. Our discussion includes changes to the English National Curriculum in 2014, experiences of self-efficacy, and the influence of family capital in parents and adult carers. We also draw upon social identity and science capital theories, and consider the lens of intersectionality to suggest how wider social inequalities and power dynamics can shape students' educational choices and trajectories. Finally, we suggest it is essential that we continue to explore social barriers to better understand how to widen participation among girls and diverse learners in computing.

Computing education in England: a brief overview

The development of technology and digital competency is widely considered as an important means for driving innovation and growth across the economy, especially since the start of the global coronavirus pandemic and associated national lockdowns (Learning & Work Institute, 2021). However, a digital crisis has been reported in the UK, where 5.4 million (or 10 % of) working adults are said to lack basic digital skills, and 4.3 million (or 8 % of) adults have no basic digital skills at all (Department for Education, 2019). The digital skills shortage persists in the labour market and has been considered a 'major risk' to business and economic development, with serious implications for society (Department for Business Innovation & Skills, 2016). It also suggests a disservice for millions of young people who may be disengaged from technology, and the vast opportunities and career prospects that can be afforded through a computing education.

Changes in the English National Curriculum from 2014 attempted to address the digital skills shortage by replacing Information Communication Technology (ICT) with a new subject, Computing (Gove, 2012). Computing places greater importance on computer science and programming, although reference is still made to computer applications, a core component of the old ICT specification, to develop safe and responsible use of technology (Brown et al., 2014). The introduction of Computing was accompanied by the creation of a new GCSE in CS, which has an increased emphasis on programming and has been positioned as a ‘rigorous, fascinating and intellectually challenging subject’ (Gove, 2012). Subsequently in September 2017, GCSE and A Level qualifications in ICT were discontinued.

Since 2014, the number of students choosing CS at GCSE has increased more than 4.5 times to just under 76,000 in 2020. However, this is still lower than the peak of the now defunct ICT GCSE, which had almost 97,000 exam entries in 2014. The number of students choosing CS at A Level has almost tripled. However, at both GCSE and A Level, the total numbers of young people choosing CS at GCSE and A Level still do not match those studying ICT in 2014. In 2020 alone, there were 25,000 fewer young people choosing any computing GCSE subject compared to 2014 (Joint Council for Qualifications (JCQ), 2020). The taught hours of computing for 11- to 18-year-olds, either for exam courses or general provision, decreased 41% between the introduction of the new curriculum in 2013 and 2020 (Kemp & Wong, 2021). Furthermore, the change in curriculum appears to have disproportionally affected some groups of young people more than others (Kemp et al., 2019).

Unequal patterns of participation

In many western countries, including England, most students engage with technology and there are few reported gender differences in terms of internet or social media usage (Office of Communications, 2015). However, in many English schools, there is a low uptake of girls in CS (Royal Society, 2017; Kemp et al., 2018). In 2020, only 22% of the 76,000 students who opted for CS at GCSE were girls. Additionally, whilst the gender gap has slightly narrowed over recent years, in 2020 there were still 27,000 fewer girls who sat any GCSE computing qualification than when the new computing curriculum was introduced in 2014 (JCQ, 2020).

Additionally, the pattern of uptake does not seem to be equally distributed between English schools. For example, girls in single sex schools have almost double the chance of sitting a GCSE in CS than those in a mixed sex school (7% vs 4%) – a pattern that is echoed in other subjects where girls are underrepresented, such as physics (Institute of Physics, 2018; Kemp et al., 2019). Students who have received pupil premium funding – that is, additional funding for children who are considered socioeconomically disadvantaged – are slightly less likely to choose CS, when in a school that offers it, than the overall student population: 23% vs 27%, respectively (Kemp et al., 2019). However, when gender and pupil premium are combined, the picture is slightly different, with 25% of girls and 21% of boys who received pupil premium funding in a school offering the subject sitting CS (Kemp et al., 2019). This pattern appears to be the case for all ethnic groups, with the exception of Chinese students, with those in receipt of pupil premium funding more likely to choose CS at GCSE.

However, a more complex picture emerges when looking at the Income Deprivation Affecting Children Index (IDACI) poverty indicator, a fine-grained scale that can be used to indicate levels of socioeconomic disadvantage in the area where a student lives. Amongst girls taking CS, socioeconomic disadvantage is positively correlated with uptake, with 7% of girls from lower socioeconomic backgrounds choosing CS versus 5% of girls from higher socioeconomic backgrounds. Interestingly, a different picture emerges for boys, where students from low socioeconomic backgrounds are less likely to study CS (21%), compared to students from high socioeconomic backgrounds (25%). The increased uptake of CS amongst girls from socioeconomically disadvantaged backgrounds (based on the IDACI poverty indicator) does not apply to Asian, Black, and Chinese girls. The trend of the most socioeconomically disadvantaged girls being more likely to take CS is heavily influenced by the larger numbers of White students in the population (Kemp et al., 2019).

Overall, the number of girls choosing CS remains low, and in the summer of 2020, consisted of only 22% of the GCSE cohort, dropping to 14% at A Level (JCQ, 2020). This low proportion of girls differs significantly from that of the previous ICT GCSE qualification, when in 2017, girls made up 43% of exam entries before the GCSE subject was discontinued.

Possible factors that influence unequal patterns of participation

Differences in student participation patterns in computing are clear, but the reasons behind them are complex. The consequences of these differences are serious for both the individuals and wider society, as computing is considered by the UK government as a subject which provides a 'strong foundation for further academic and vocational study, and for employment' (Department for Education, 2015, p. 10). Here, we discuss some of the possible factors that influence unequal patterns of participation with computing.

Curriculum

With the new GCSE CS curriculum introduced in 2014, students are developing greater skills in computational thinking that meet the demands of the economy, including coding, e-safety, networking and data storage (Larke, 2019; Williamson, 2017). As mentioned earlier, with the focus on digital knowledge, former (and often more popular) elements of the ICT qualification have been replaced with a greater focus on coding and programming as core components of the CS GCSE course. The emphasis on academic 'rigour' and 'intellectual challenge' within the subject may further dissuade young people whose self-concept is far removed from that of the idealised computer science student. Analysis of exam results position the CS qualification as one of the hardest GCSEs for students to achieve well at, while analysis of the ICT GCSE shows results in line with other courses. This calls into question the narrative that ICT was an easy course, at least at GCSE (Kemp et al, 2019; Kemp & Wong, 2021). There are therefore concerns that whilst the computing curriculum might help to increase numbers of future computer scientists, programmers or technology entrepreneurs, it may also exacerbate social inequalities by only appealing to students from particular demographics or with particular characteristics (especially boys), or to students with higher levels of access to computing resources, knowledges and contacts (Wong & Kemp, 2018). In addition to changes to the curriculum, there may be additional issues such as subject timetabling in schools and computing teacher recruitment, development and retention. Students' GCSE and A Level choices are largely influenced by the hours and options made available to them, especially given the nature of post-sixteen entry requirements, where CS may be regarded as less desirable, useful or necessary compared to other subjects that are timetabled to run concurrently (Abrahams, 2018).

Self-efficacy

Differences in self-efficacy can influence the ways in which students identify and participate in computing. Self-efficacy is a self-belief which can be shaped by a number of individual and social factors (Bandura, 1999; as elaborated elsewhere, see SCARI Computing, 2021). For example, students' self-evaluations of past performances when undertaking a task in computing (e.g., writing lines of code) are likely to determine their attitude towards undertaking the task again in the future. Similarly, self-efficacy may be influenced by observations of peers and perceptions of peer success. If a learner observes their classmates undertaking a task successfully, they might believe that they also stand a chance of completing the task (i.e. 'if they can do it, so can I'). A learner may also be influenced by 'social persuasion' from peers, teachers or parents, or 'emotional responses' to a task or event (e.g., sitting a computing exam), which may reduce levels of self-efficacy due to high levels of anxiety around its outcome.

In the context of secondary education, self-efficacy in computing might predict a young person's choice to study computing. While this area of education currently remains underexplored, girls' perceptions of computing and mathematical self-efficacy have been said to correlate with their participation in CS (Lips & Temple, 1990). Overall, girls seem to achieve slightly lower exam results in CS (and STEM) than their other subjects, especially subjects such as English, where relative performance in CS has been found to be most acute when controlling for average attainment scores (Kemp et al., 2019; Kemp & Wong, 2021). This would assume that all learners work just as hard in school, but disparities in outcomes between subjects suggest girls may contribute to lower feelings of self-efficacy in CS. Similarly, a substantial number of studies have demonstrated gender differences in self-efficacy relative to computing, especially those that involve advanced computing skills (Cassidy & Eachus, 2002; Huang, 2013; Torkzadeh & Koufteros, 1994).

Family capital in parents/adult carers

Furthermore, there is a strong but complex link between a child's relationships with their adult carers (including parents, extended family and their teachers) and whether a young person chooses to study STEM subjects (e.g. Archer et al., 2012; Jones & Hamer, in press). There is now considerable evidence that parents' or carers' own views in relation to subject choice and career options have important outcomes for their children. For example, Jacobs et al. (2006) demonstrated that parents' gendered attitudes towards the occupation expectations of their child at the age of 15, are closely linked to their child's own aspirations at the age of 17. Not only that, but parents' gendered expectations of jobs for their child at the age of 17 were found to be related to the actual job the child had at 28. If a parent or teacher has a greater interest in computing and minimally gendered views, it would perhaps be unsurprising that they would be more likely to consider computing as an option for the young people in their care. Therefore, values and expectations shared by parents, relatives and/or teachers, through discussions at home or in school, may shape a young person's aspirations and perceptions of computing as a viable option for themselves (e.g. Wong, 2017). It would then seem possible that a teacher, family member or peer may also positively reinforce beliefs that a young person has by telling them that they believe they can complete a computing task (or 'become' a computing person) (SCARI Computing, 2021).

Social identity and science capital

Students as individuals bring with them a unique array of skills, perceptions and experiences which can shape their attitudes and performances in different subjects. Students may have different levels of access to computing resources, knowledge and contacts. There may also be different cultural expectations of success and financial security, and opportunities can vary across subjects. In the context of STEM, these factors can either increase or lower a young person's *science capital*, and may influence their decision to study STEM subjects (Archer et al., 2015; Bourdieu, 1977; Moote et al., 2020; Wong, 2012). In other words, if a learner has a high science capital, they are more likely to opt for science-related subjects, so we might suggest that if students have a high *computing capital*, they are more likely to opt for a computing education and aspire for a computing-based career.

However, notions of identity are complex and shaped by social constructions such as gender, ethnicity and social class. Unequal patterns of participation in CS may unfortunately be a product of powerful perceptions of what is considered 'normal' or 'appropriate' for students depending on their social demographics, identity expressions or locations (e.g. where they live, go to school, etc.). These factors are said to influence students' educational choices and trajectories (Archer et al., 2010; Bourdieu & Passeron, 1977). Research suggests that even when young people report enjoying STEM subjects, finding them 'fun', 'exciting', 'important' or 'interesting', they may still consider them as 'not for me' (Archer et al., 2010; Jenkins & Nelson, 2005). Young people's interest and engagement with STEM, which includes computing, are therefore likely to be shaped by their social positionings, and the specific gendered, racialised and classed identity constructions that are considered socially desirable.

Indeed, some constructions of a 'computing' identity may be ruled out as socially *undesirable*. Stereotypes such as 'geeks', 'nerds' and 'hackers' are gendered as typically masculine (e.g. 'antisocial' and 'technical') (Varma, 2007), racialised as white (Mendick & Francis, 2012), and reaffirmed by mainstream discourses, movies and media portrayals of computing enthusiasts and specialists (e.g. representations of scientists on *The Big Bang Theory*) (Wong, 2017). Depictions of white, privately educated, male leaders of tech giants, like Bill Gates, Steve Jobs, Elon Musk and Mark Zuckerberg, are frequently used to inspire students in computing in the forms of pictures, quotations or wall displays. While this might work for some students, it highlights the lack of known role models who identify differently to the stereotypical white, privately educated man, potentially reinforcing damaging ideologies that the latter is better suited for careers in computer science and technology, and that business and commercial outcomes are the end result of the study of computing (Wong & Kemp, 2018).

In other words, girls can certainly 'do' computing, but may struggle to aspire to a computing education because they do not 'fit the label' of what constitutes a 'typical' computing person (Archer et al., 2010; Wong, 2017). This suggests social inequalities can deter girls and minorities from identifying with and participating in a computing education. Alternatively, they may seek more desirable identity expressions through participation in other subjects (Archer et al., 2010). National statistics indicate that girls were most represented in subjects such as Health and Social Care, and Art and Design, and least represented in CS (JCQ, 2020). Yet, the experiences, representations and performances of gender minority learners remain underexplored. Mindful of these social inequalities, science capital is likely to vary among students depending on their resources and knowledge, and may help to explain the underrepresentation of girls, especially from diverse backgrounds, in computing.

Intersectionality

Another way to interpret unequal patterns of participation in CS may be through the lens of intersectionality (Crenshaw, 1989), which identifies intersecting modes of inequality that occur on the basis of sex, gender, race, ethnicity, sexuality, disability, neurodivergence, and so on. Intersectionality allows for a deeper understanding of the different ways students might experience social inequalities, and how systems of power can discriminate against multiple characteristics and social demographics at any one time. Therefore, students who are not represented by the majority – whether in terms of gender, ethnicity, or any other dimension of social identity – may experience multiple, intersecting inequalities or barriers, such as sexism, gender discrimination, and racism, that are likely to shape their educational choices and trajectories.

For example, the social stereotypes described in the previous section may transpire to (un)conscious biases (and vice versa), which may exacerbate social inequalities further. There is evidence to suggest that gender differences exist in teacher-student interactions in physics classrooms, where boys have been found in some schools to dominate classroom interactions, either by calling out or volunteering answers more often than their peers (Institute of Physics, 2016). There may also be additional factors that shape social assumptions about who has the knowledge capacity or cultural competence to complete certain tasks. The perception that a student must be 'really smart' to do CS seems to persist among both students and staff (Margolis et al., 2017). Yet, there seems to be little criticality about the subjectivity of intelligence and how it is measured in the context of computing. This is important when we consider whose knowledge counts and why, and the types of knowledges and skills that are valued over others (Schucan Bird et al., 2020). If diverse learners feel underrepresented, unheard or undervalued in the computing classroom, they may experience a lower sense of self-concept or belonging, which has been said to impact student engagement, attainment and retention (Gandolfi, 2021). Intersectionality is therefore a useful theoretical tool for understanding students' unique experiences of social inequalities, and how they may play out in the computing classroom to cause unequal patterns of participation.

What next?

The evident lack of girls and certain minorities choosing computing-related subjects at both GCSE and A Level should be of concern to us all, as it likely reflects an inequality that will have reverberations in the workplace and wider society for years to come. If patterns of uptake for GCSE CS persist and computing continues to be side-lined in English school timetables, a significant proportion of a generation of young people will continue to miss out on the enjoyment and opportunity that computing has to offer. The reasons for the decline in girls in computing education are myriad and complex, but it is essential that we continue to explore the barriers faced by young people in schools and wider society. By understanding the reasons for unequal participation, we may learn how to better keep the door open to the world of opportunities that are afforded through a computing education.

About the SCARI Computing project

The SCARI Computing project aims to explore the factors that explain the participation and performance of girls in English secondary school computing with a particular focus on CS exams. The study will use the National Pupil Dataset and School Workforce Census, alongside school case studies through quantitative and qualitative data collected from school managers, students, and documents, such as schemes of work and wall displays. We will be working with schools with a high uptake in GCSE CS to understand the views of their students and staff, through student surveys, staff interviews, and to learn from their computing curriculums. We hope this will inform our current understanding of girls' participation in computer science, as well as impact policies and educational interventions to reduce the participation and attainment gaps between diverse students in computing education.

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Visit www.nuffieldfoundation.org

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