Computing skills, beliefs and identities in young people from underserved communities

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***Abstract*—Despite increasing access to computing curricula within schools, the number of young people from diverse backgrounds choosing computing qualifications and careers is still low. It is important to understand the reasons for this lack of engagement directly from young people in order to identify potential avenues for intervention. Furthermore, it is vital to consider these reasons within their specific educational and social contexts. This qualitative pilot study aimed to provide insight into how young people from underserved communities in the United Kingdom viewed computing and how it related to their current lives and future aspirations. We interviewed thirteen young people, aged 9-22, who were at risk of educational disadvantage. Thematic analyses identified a mismatch between a stereotyped computing identity and the identities or personal interests of the young people. Although they felt comfortable with using computers in general, the young people seemed to lack belief in their own ability, or to understate it, during the interviews. Future research should expand on these themes and take an intersectional approach to promote context-specific interventions and support to encourage a more diverse workforce in computer science.**

***Index Terms*—broadening participation, computing education, identity, self-efficacy, educational disadvantage**

I. Introduction

In the United Kingdom (UK), computing is taught in some form in all schools across K-12. While this means that all children have an entitlement to a computing curriculum, an issue still persists in the number of females, as well as young people from low-income families and some ethnic groups, who choose to continue with computing past the compulsory age and into their later careers [1]. This mirrors levels of participation in computing in other Western countries which do not have a mandatory computing curriculum [2], [3]. It suggests that universal access to computing in school is not enough to keep diverse communities engaged and that more needs to be done to understand young people's attitudes and beliefs towards computing as a subject and as a future career.

Recent school closures and lockdowns due to the global pandemic have increased educational inequality, with many disadvantaged young people having little or no access to suitable technology for home learning [4], [5]. Within this context, the Raspberry Pi Foundation has been working with youth and community organisations around the country to provide free computers to those at risk of educational disadvantage in underserved communities. As part of this programme, we conducted a pilot study to speak with some of the young people about their experiences of computing, their attitudes towards the subject, and how it fits into their future plans.

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II. Background

In England, only 10-20 percent of students taking optional qualifications in Computer Science (CS) in high school are female, and those from more low-income backgrounds and of African/Caribbean descent are most proportionally underrepresented in the subject [1], [6]. Previous research has highlighted a number of structural, social, and psychological explanations for this lack of diversity in CS qualifications and careers, including reduced access to computing in and out of school [2], [3], narrow stereotypes of computer scientists [7]–[9], and lack of interest and confidence in the subject [10]–[12].

In terms of access, while all schools are required to teach computing in some form in the UK, they do not all offer CS qualifications after the age of 14. Thus not all young people have the same level of access to continuing CS education, and this may disproportionately affect some groups more than others [12]. A lack of diverse representation within computing may lead to a "fallacious archetype" of a computer scientist being male, white, middle-high socioeconomic status, and young [8, p. 220], which seems to permeate Western culture. Stereotypes about computer scientists are evident relatively early: 10-14 year-olds in the US who were asked to draw a computer scientist were significantly more likely to draw a male than a female [9], to show the computer scientist wearing glasses, and to describe them as smart or geeky/nerdy [9], [13].

Having narrow stereotypes of computer scientists can conflict with a young person's own sense of identity or desire to fit in with a peer group or appear 'cool'; there is often a disconnect between young people "doing computing and being a computer person" [11, p. 299]. It can also affect interest in a subject; if students believe that computer scientists reflect "geek culture" [14, p. 360], which does not appeal to them personally, then they may fail to see the relevance of CS to their lives and future careers.

A further important psychological factor is students' computing self-efficacy, or their confidence in their ability to undertake particular tasks [15]. Research has reported relatively high levels of computing self-efficacy early in high school,

but suggests this tends to decrease with age [12]. Male students tend to have higher computing self-efficacy than female students, and their confidence is usually better calibrated to their actual performance than females (who are more likely to underestimate their ability; [16]). Computing self-efficacy may also be indirectly affected by socioeconomic background, for example through a reduction in the opportunities to develop skills outside of school [11].

Much of the previous work relating to the under-representation of people from low-income communities in computing has been based in the United States or countries where the teaching of computing is not mandatory. The focus may be on *access* to computing, through the *capacity* of schools to teach CS, and students' access to courses and equipment. The CAPE framework [17] highlights that capacity and access to computing (C and A in the framework, respectively) are only part of the challenge in making CS equitable; students' *participation* (P) in and *experience* (E) of computing are key factors in keeping them engaged over the longer term.

In England, mandatory computing education provides more equitable capacity and access to computing in schools than in other countries, but participation by students from low-income backgrounds in CS qualifications is often still low [1], [6], although this can differ based on gender and ethnicity [6]. Very little work has been done in this context concerning these students' experience of computing. One study that was conducted in the UK reported on 13-19 year-old young people's views and experiences of computing in and out of school [11]. However, the young people were attending a computing summer school and were therefore likely to be interested in computing, which may not be representative of students from low-income families.

Building on previous research, the present pilot study focused on a group of young people who were from low-income communities who were at risk of educational disadvantage due to lack of access to computers for school work. They represented a wide age range, as well as different ethnicities and genders. Specifically, we aimed to address the following research question: *How do young people from underserved communities feel about computing and their own digital skills?*

III. Methods

Interviews conducted in this study were part of a larger evaluation process measuring the impact of a scheme to deliver computers to young people at risk of educational disadvantage. From 947 young people receiving computers in the first wave of the programme, 24 who had agreed to be contacted for research purposes were shortlisted, representing different areas of the country along with a mixture of gender, ages and ethnicities. Nine young people did not reply to the interview request, resulting in an initial sample of 15 interviewees.

The young people and their families who agreed to be contacted were sent an information sheet explaining the topics to be covered in the interview (see below), how their data would be used, and their right to withdraw at any time without affecting any ongoing or future support from the organisation. This information was repeated at the beginning of the interview to ensure comprehension. All interviewees under 18 had their case worker from their organisation and/or a parent present. Interviews lasted up to 30 minutes and were conducted via video or telephone call, depending on the young person's preference.

After the interviews, one young person's data were excluded from analyses because it was clear during the interview that he had low language proficiency and struggled to understand the questions and respond. A further young person's data were excluded because the parent often interrupted and the data collected were therefore not reliable.

The young people were identified to receive the computers because they belonged to underserved communities and therefore tended to be from lower socioeconomic backgrounds. Many of them did not have a computer at home for academic work before participating in the programme, although most had access to some digital device (most often a cellphone). Demographic information for the thirteen interviewees in the final sample are presented in Table I. The sample consisted of six females and seven males, and around half of the interviewees identified as White British.

TABLE I
DEMOGRAPHIC INFORMATION FOR THE THIRTEEN INTERVIEWEES

Interviewee	Age	Sex	Ethnicity
i-1	13	Male	White British
i-2	13	Female	White British
i-3	16	Male	White British
i-4	11	Female	Asian
i-5	19	Male	White British/Caribbean
i-6	9	Female	Black British
i-7	22	Female	White African/Caribbean
i-8	13	Male	Black African
i-9	13	Female	Asian
i-10	15	Male	Black British
i-11	16	Male	White British
i-12	16	Female	White British
i-13	17	Male	White British

Interviews focused on the young people's feelings about computing, specifically their own self-efficacy and feelings of belonging in the discipline, the type of people they thought of as 'computer people', and whether computers would be important for their future careers. Once the interviews were conducted and transcribed, thematic analysis was used to search for themes and patterns in the data [18]. First, the researchers read through the transcripts and, through an iterative process, agreed on a set of codes. These were then used to code the interviews, after which major themes were identified. The researchers met frequently to discuss the coding process and to agree on certain interpretations of the data, while acknowledging their own positions in relation to the social context of the study.

IV. Findings

Two main themes were identified across the interviews. The first theme, **mismatch between computing and own**

identities, had three main elements: the interviewees' *underlying beliefs about 'computer people'*, their *self-perception in computing*, and *gender conventions in career aspirations*. The second theme, **understated self-efficacy**, consisted of a sense of the interviewees *holding back* in how they presented their computing ability, and reports of a range of *barriers to computing*. The themes are described in more detail below.

A. Theme 1: Mismatch between computing and own identities

1) Underlying beliefs about 'computer people': From the interviews it became clear that the majority of the young people described a 'computer person' as someone who is smart, clever, and/or intelligent, as exemplified by this quote: "A bit smart. Very, very logical, because computers are very logical. Things like smart, clever, intelligent, because computers are quite hard. Really skilled, maybe" (i-2). Two interviewees characterised this imaginary person as someone who is nerdy or geeky: "Intelligent, logistic, I wouldn't say nerd but... No, actually, yes, I would say nerd. Nothing bad about that" (i-1). And two others said this person would be good at problem solving.

When asked to describe the looks of this 'computer person', most of the interviewees said that it could be anyone: "I don't think it's like a person with glasses and all that. I think I know loads of different people. I use computers now, do you know what I mean?" (i-11). When it comes to gender, however, four interviewees were more likely to associate this person with being male: "Oh, they're a boy, and they have loads of technology stuff in their house" (i-4).Three of these responses came from females, indicating potential identity issues surrounding computing when it comes to gender [14]. What these stereotypes suggest is that while anyone could be a computer person, this person would also likely need to be smart, clever or intelligent, and in some cases, a male.

2) Self-perception in computing: The majority of the young people in the study said that they could be this 'computer person'. Even for those who did not see themselves working with computers in the future, being a 'computer person' was still a possibility: "I feel like maybe, yes. I feel like I'm quite good at using a computer. I know my way around. Yes, you never know. I could be, eventually" (i-7). For others, some work was still required to become one: "I think so. I think I'd have to work quite hard at it, but I think I could be" (i-2).

For those who were unsure about being a 'computer person', this was mostly because their view of computing did not match with their view of themselves or their personal interests: "Well, I don't know. I'm more of a practical person" (i-11). One other interviewee did not see herself doing the things that a 'computer person' does: "I do use the computer, but I'm not an expert at it. And I feel like, with the computer, it relates to loads of online games. I don't normally play those kind of stuff. ... Maybe, I don't know. I think I could change my opinion of computering [sic] a bit, but I don't think I would be a 'computer person', I guess" (i-4).

This mismatch between the computing identities of digitally skilled youths and the assumed identities of computing professionals fits with previous research in which young people construed computing enthusiasts as people who are different and "not like us" [11, p. 310]. That study found that popular stereotypes of computing enthusiasts still persist, with "committed, analytical, clever but antisocial" as popular associations [11, p. 305]. There is an interesting similarity with the stereotypes found in our study, namely "smart, clever, intelligent" and to some extent "nerdy" and good at "problem solving". We found that none of the young people in the current study had a strong identity as a 'computer person', however they did feel that they could become one through hard work, improving their mathematical skills, and putting their minds to it. It is not immediately obvious to them that perhaps they are 'computer people' already, even for those who chose computing in school, or who are already digitally skilled. As in previous research [11], there is a distinction between doing computing, for instance in school, during leisure time, or for creative things, and being a 'computer person'.

3) Gender conventions in career aspirations: When asked about their future career aspirations, only two interviewees wanted to pursue a career within computing, as developers in games and software. Both identified as White males, fitting with the archetypal stereotype of computer scientists [8]. Other careers for the male interviewees included two engineers, a plumber, a paramedic or electrician, and sports. For the female participants, two of them wanted to become an architect, and three jobs related to healthcare: doctor, nurse, and midwife. It is interesting to note here how the males chose jobs related to computing or engineering, with some vocational professions, whereas the females were were more likely to choose roles in caring professions. Previous research suggests that young people, especially females, might be put off from a career in computing because of social and cultural ideas associated with being a computer scientist [10]. Previously the interviewees described a 'computer person' as a boy, smart, or nerdy. Individuals who do not perceive themselves as such will be discouraged from adopting a similar identity [11], [14]. However, it was evident that even those who did not wish to pursue computing as a career understood the potential value of it to their chosen profession, as one of the females who aspired to become an architect explained: "because if I want to make structures on computers, or 3D models, then I'm obviously going to use a computer, so I'm going to need Computer Science" (i-9).

B. Theme 2: Understated self-efficacy

1) 'Holding back': From the interviews it became clear that a majority of the young people felt like they were good at using computers. They spoke about making games (i-6), 3D modelling (i-3), programming in HTML (i-1), making music (i-8) or websites (i-7), and fixing problems on the computer (i-9). One interviewee said "compared to some of my teachers who don't know that Ctrl+C and Ctrl+V are a thing, I would say I'm pretty good. Maybe not a computer wizard that knows everything about what he's doing, but I know some things. I can do things" (i-1). Another interviewee also talked about

picking up digital skills during computing at school: "We have done ICT from Year 7 all the way to Year 10. I think I know what I'm doing" (i-7). Both males and females reported similar self-efficacy in computing.

Despite this, the interviewees also tended to hold back from saying they were able to become a 'computer person', perhaps due to modesty or not fully believing in their own abilities. One young person specifically wanted to become a game developer, indicated that he had access to different digital technologies, was thinking of studying computer science, and acknowledged he had relatives who work in the field of computer science. Nevertheless, the young person felt there was more to being a computer person: "I would say I already am to some extent, but I could definitely be more" (i-1). Similar uncertainty was present for two other young people who, although they indicated they were good at computers, said they "had to put their mind to it" (i-12), or "could be one eventually" (i-7).

2) Barriers to computing: For those five young people who indicated relatively lower self-efficacy in computing, more barriers to becoming a computer person were reported. For one young person, mathematics was an issue: "My maths is okay, but not the best. In the future, most probably. But right now, no" (i-13). One young person who wanted to pursue a career in sports said that computers were not really his "style" (i-5). It is interesting to note how self-efficacy in computing, whether high or average, does not make young people associate more or less with a computing identity. Even for those who were digitally skilled, or seemed destined to pursue a computing career, there were still barriers reported in order to become a computer person. As Wong [11] has pointed out, an identity in computing seems to consist of highly stereotyped attributes and expectations. What this means, in the context of this study, is that young people set high expectations of computer scientists, in effect making it harder for themselves to relate to. Although young people are digitally skilled, and able to become computer scientists, it seems difficult for them to acknowledge that they meet the high standards they imagine for these people.

V. Discussion

Given the differences in educational and social contexts across countries, it is important to understand which factors tend to be more commonly associated with young people disengaging with CS, and which influences are more country-specific. Confirming previous reports that young people often have a narrow stereotype of computer scientists [9], [11], participants in the current study tended to identify those who were good at computing as "smart" or "geeky", with half the females suggesting these people would more likely be male. Interestingly, the male participants tended to be more open in terms of the characteristics of a computer scientist, although they still highlighted the need to be intelligent and focused on gaming or computing in a broader sense. The concept of "geek culture" [14, p. 360] thus still seems to surround CS as a discipline, and is likely discouraging many young people from continuing to engage with computing.

The general agreement about the high level of intelligence needed for CS also seems to be a negative influence on the young people's enthusiasm for computing in the present study. In some ways it seems that being digitally skilled is not enough to be a computer scientist, and those who continue in computing are somehow "not like us" [11, p. 306]. Unlike in some previous research, females were just as likely to report confidence in their digital skills as males, although both sexes tended to understate how good they were in comparison to an idealised view of a computer scientist. This may have been due in some part to the nature of the interview, which was conducted with an unfamiliar adult, and may have affected the young person's self-presentation [19]. For example, it may have caused them to play down their ability, so as not to appear arrogant, in an attempt to gain social approval [20]. It may also have been related to their backgrounds in underserved communities; most of the interviewees had only started having access to a home computer for academic work by participating in the programme, and are therefore less likely to have been able to practice skills outside of school or develop greater interest in the subject [11].

The current study allowed us to focus on young people from low-income families, although the diversity within the sample meant we could also examine other characteristics. Interviewees presented very similar attitudes and beliefs about computing, including who it was for, and whether it would be used for their future career goals. Only two White male participants considered computing as a career, with one White female interviewee understanding that choosing it as a qualification might be important for her future career. This aligns with statistics from CS qualification choice at age 14 in England, which highlight the interaction between income, gender, and ethnicity: White females from lower-income families are more likely to choose CS than their more affluent counterparts, but females from Asian, Black and Chinese low-income backgrounds are very poorly represented in CS qualifications [6].

VI. Conclusion and Further Work

The current study aimed to assess whether factors affecting young people's engagement with computing in other educational and social contexts were similar in the UK, specifically amongst those who were at risk of educational disadvantage. Narrow stereotypes of computer scientists do seem to prevail, highlighting that interventions developed elsewhere to improve diversity in representations of computer scientists and computing as a career could also be applied in the UK [13]. More detailed interviews concerning identity, self-efficacy, and different demographic characteristics, will be important to better understand these complex issues from an intersectional perspective and from a wider range of young people. This will enable context-specific interventions and support to be put into place to ensure computer science attracts a more diverse and representative workforce.

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