Hayley C. Leonard (Raspberry Pi Computing Education Research Centre, University of Cambridge)
Thom Kunkeler (Raspberry Pi Computing Education Research Centre, University of Cambridge)

Why the ‘digital divide’ does not stop at access.

Leonard, H. C. and Kunkeler, T. (2021). Why the ‘digital divide’ does not stop at access. In Understanding Computing Education (Vol 2): Equity, Diversity and Inclusion. Proceedings of the Raspberry Pi Foundation Research Seminars.

Available at: rpf.io/seminar-proceedings-vol-2

Why the 'digital divide' does not stop at access

Hayley C. Leonard (Raspberry Pi Computing Education Research Centre, University of Cambridge)
Thom Kunkeler (Raspberry Pi Computing Education Research Centre, University of Cambridge)

Abstract

Around the world, young people from socially and economically disadvantaged backgrounds are less likely to have access to a home computer and to computing at school, and are underrepresented in computing-related qualifications and careers. In the United Kingdom, although all children in school have access to a mandatory computing curriculum in some form, the uptake of computing qualifications and careers amongst those from low-income families is still low. In this chapter, we will discuss some of the complex issues that contribute to these outcomes. First, we will consider the term 'digital divide', which is used widely to discuss inequality in access to technology and digital skills. We will then introduce a framework for assessing equity in computing education that includes, but is not limited to, access. This helps us to identify key aspects of the educational journey for young people where we can most usefully focus our efforts to support those from low-income families. We will present the results of interviews we conducted with a group of young people at risk of educational disadvantage, focusing on their attitudes towards computing as a discipline and their own digital capabilities.

What is the digital divide?

According to the Close the Gap Foundation (2021), the digital divide is defined as *"the gap that exists between those who have reliable internet access and devices and those with very limited access or none at all"*. Research into the digital divide began by focusing on this concept of access, specifically to the internet, and the negative consequences on social and economic mobility that resulted from its limitation or absence (Scheerder et al., 2017). This conceptualisation leads to an expectation that improving internet infrastructure and saturation around the world would reduce the inequalities between those with and without access, but this has not been the case (Van Deursen & Van Dijk, 2019).

Understanding of the digital divide has evolved over time and now tends to be split into different levels: the first being access to technology, the second being the skills required and the use of technology, and the third being the outcomes of this use (Scheerder et al., 2017). For example, in terms of skills, the ability to use technology competently for the purposes of accessing emails or social media differs from being able to design, create and publish unique content through websites or other tools (Van Deursen et al., 2016). Those who develop the more complex skills have more opportunities to improve their economic position through a wider range of

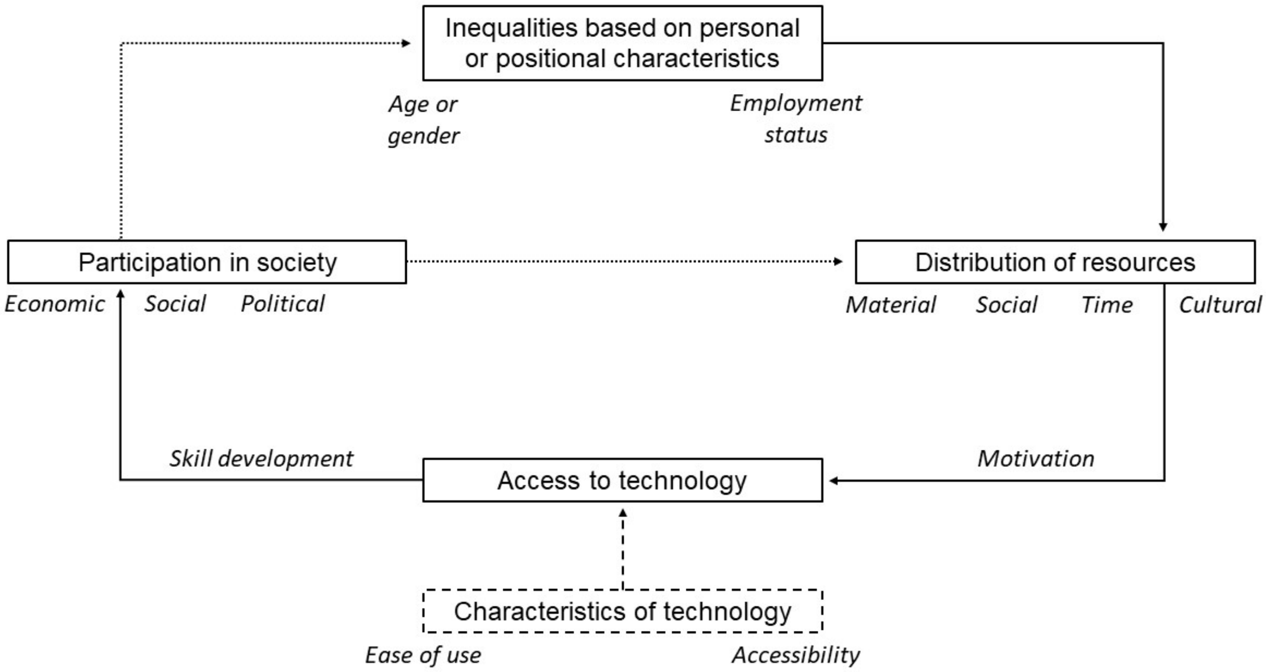

Figure 1. Representation of the Resources and Appropriation Theory (Van Dijk, 2005), highlighting the cyclical nature of inequality in technology use. Note: Adapted from Van Dijk (2013).

employment prospects. While initial access is of great importance, there are thus additional levels of the digital divide that can compound inequalities between people in society.

Van Dijk (2005) introduced the Resources and Appropriation Theory to provide an explanation of how new technologies are distributed, accessed, and used, and how this contributes to ongoing inequality in society (see Figure 1). In the first stage of the causal model, Van Dijk (2013) identifies the aspects of an individual's identity (such as age or ethnicity) and their position in society (such as employment status or the nation in which they live) which often result in unequal distribution of resources. These resources may be the physical materials themselves, but can also include having the time or skills to use these materials, the social support to learn how to use them, and the cultural environment to value and therefore want to use them.

For young people in education, their personal and positional characteristics may affect the material resources available to them even within the school environment, with schools in less affluent areas perhaps having lower quality technology. They may then also have more limited time outside of school to engage in extracurricular activities to develop their skills, and fewer role models or social connections who have access to technology and technological competence.

Van Dijk (2013) explains how access to

technologies does not only involve having the physical materials, but also the appropriate equipment to maintain access, such as relevant software, ink, etc. Furthermore, it depends on the individual's skills in using the technologies, which are influenced by the characteristics of the materials: for example, introducing a technology to a novice that involves long, complex processes and detailed knowledge is likely to result in that person giving up or not being able to advance their use of the technology. This can in turn lead to reduced participation in a number of areas of society, including economic and social mobility and political participation, which can feed back into personal and positional inequalities and produce a cycle that is difficult to break. This element of the model has implications for education, highlighting the importance of high quality instruction, introducing appropriate and incremental challenges into teaching computing, and encouraging resilience and persistence.

The model highlights the complex and cyclical nature of inequality in technological use, moving on from a simple definition of a digital divide between those who do or do not have access to technology. As outlined above, the model also provides some insights for computing education in terms of how we support young people in developing their skills and knowledge. The next section focuses on equity in computing education specifically, describing a framework developed in the United States (US) and considering its implications for the United Kingdom (UK) context.

A framework for assessing equity in computing education

In England, only 10-20 percent of students taking optional qualifications in computer science (CS) in high school are female, and those from lower-income backgrounds and of African/Caribbean descent are most proportionally underrepresented in the subject (Kemp et al., 2018, 2019). This is despite the fact that computing is a mandatory subject between the ages of 5 and 16 and therefore all children have access to a computing curriculum in some form. In the US, computing education is not mandatory but there is a similar underrepresentation of certain groups in CS qualifications (Code.org, CSTA & ECEP Alliance, 2020). There appear to be a number of structural, social and psychological barriers that prevent young people with particular personal and positional characteristics (Van Dijk, 2005) persisting with CS qualifications and careers.

Researchers in the US have developed a framework for assessing some of these barriers to equity in computing education, using the acronym CAPE to represent issues with *Capacity, Access, Participation, and Experience* (Fletcher & Warner, 2020; see Figure 2). We will now discuss each of these aspects of the framework in more detail.

Capacity and access

The first two levels of the CAPE framework represent the capacity for providing computing education, and the consequent access that students have to computing instruction. These levels reflect the distribution of resources in Van Dijk's (2005) Resources and Appropriation Theory. Schools in lower-income areas in the US tend to have fewer certified computer science teachers and funding for teacher professional development, meaning that students are less likely to be able to access high quality instruction or to be offered opportunities to study CS in their schools (Fletcher & Warner, 2020).

In England, the Department for Education has invested in computing education capacity, funding the National Centre for Computing Education which includes professional

Figure 2. Levels of the CAPE framework for assessing equity in computing education. Note: Adapted from Fletcher & Warner (2020).

development and training for teachers, the production of a freely accessible computing curriculum, and community support. The aim is to reduce or remove the inequalities between different societal groups through the school system.

However, it is important to note that, although capacity and access issues are addressed within schools, this does not overcome the inequalities present outside of school. This existing problem has recently been highlighted by the COVID-19 pandemic, during which it was clear that many young people did not have the technology available at home to be able to engage with their learning outside of school.

A report from the Sutton Trust showed that 35% of parents from low-income communities had no access to a sufficient number of devices in the home to support their children in their schoolwork, compared to 11% in higher-income schools. In addition, the number of students in schools without internet access at home was much greater for low-income families from state schools than more affluent state schools and private schools (Montacute & Cullinane, 2021). The attainment gap between those from lower- and higher-income families (e.g. Andrews et al. 2017; Tuckett et al., 2021) is evidence that inequalities outside of the classroom still affect the distribution of resources and academic outcomes of those from less advantaged backgrounds, and these inequalities have been compounded by the COVID-19 pandemic (Montacute & Cullinane, 2021).

Participation and experience

Once the building blocks of capacity for and access to computing education are in place, the CAPE framework identifies two further elements required to ensure that computing education is equitable: participation and experience. Participation refers to those who elect to study computing when it is not mandatory, while experience relates to the outcomes of this participation in terms of enjoyment, interest, learning gains, and future study and careers (Fletcher & Warner, 2020).

As described earlier, a number of groups are underrepresented in computer science in both the US and UK when the subject is elective (e.g. for higher qualifications). Research has suggested that competence and self-efficacy are important factors in maintaining interest in a subject, as well as motivating an individual to invest time and effort into it to pursue studies or careers in that field (Denner & Campe, 2018). Without opportunities to practise computing and digital making outside of the classroom, young people will not develop the same level of competence or expectations of success as their peers who have access to a computer at home and/or extracurricular activities, even if access within schools is becoming more equitable. Teachers suggest that young people with these sorts of access issues may be put off or feel out of their depth in classrooms with peers who sound very confident about their computing experience and expertise (Gretter et al., 2019), and this could have a negative effect on those from low-income backgrounds in particular.

Students' perceptions of CS as a discipline and a career may also affect their subject choices. Stereotypes about computer scientists being male, wearing glasses, and being 'nerdy' or 'geeky' are evident between 10 and 14 years old (Pantic et al., 2018; Denner et al., 2012). These narrow stereotypes can conflict with a young person's own sense of identity, or create a disconnect between the perception of someone who is competent with computers and someone who is a computer scientist (or between "doing computing and being a computer person"; Wong, 2017, p.299).

Stereotypes can also affect how interested students are in a subject or how relevant they see it to their future careers. In families who have little access to technology and limited understanding of CS as a discipline, young people are likely to have less exposure to a range of people involved in computing, and fewer opportunities to challenge stereotypes. This lack of family knowledge, skills and social connections (or resources, in Van Dijk's model) affects the career aspirations of young people for jobs in science more broadly (Archer et al., 2020) and may have a similar impact on computing career aspirations.

To understand young people's experiences of computing, it is necessary to speak with them directly. Those from low-income families may be less likely to be represented in research (Heinrich et al., 2010) due to a number of complex factors, but it is vital that their voices are heard to achieve equity in computing education. Very little research has been conducted on the experiences of young people from low-income families in computing, and the few studies that do exist tend to be based in the US. One study from the UK interviewed young people aged 13-19 who were attending a computing summer school, and asked them about their experiences of computing in and out of school (Wong, 2017). Despite being relatively interested in computing, as demonstrated by their attendance at the summer camp, they reported many of the narrow stereotypes of computer scientists outlined above, as well as a lack of aspiration towards computing careers.

The next section of this paper outlines a pilot study that we conducted with young people from low-income families to better understand their experiences of computing, focusing on those who had limited or no access to computing devices or the internet at home.

Figure 3. Some of the young people who received their computers as part of the Learn at Home campaign.

Speaking to young people about computing

At the Raspberry Pi Foundation, we recently set up a campaign to engage and support young people at risk of educational disadvantage due to the COVID-19 pandemic (the Learn at Home campaign[6]).

The scheme worked with a number of youth and community organisation partners to provide free computing equipment, internet connectivity, and digital support to young people who were unable to access their school work during school closures. A central part of this scheme was talking to the young people and their families about its impact on their ability to engage with their school work, as well as to communicate with teachers and peers. Some of the young people also agreed to participate in interviews for research purposes, and the study we undertook is described in more detail below (for the full study, please see Kunkeler & Leonard, 2021). We aimed to address the following research question: *How do young people from underserved communities feel about computing and their own digital skills?*

Method

Participants

The first wave of the Learn at Home campaign

[6] https://www.raspberrypi.org/blog/closing-the-digital-divide-with-raspberry-pi-computers/

Table 1. Demographic information for the thirteen interviewees.

Interviewee	Interviewee	Interviewee	Interviewee
1	13	Male	White British
2	13	Female	White British
3	16	Male	White British
4	11	Female	Asian
5	19	Male	White British/Carribean
6	9	Female	Black British
7	22	Female	White African/Carribean
8	13	Male	Black African
9	13	Female	Asian
10	15	Male	Black British
11	16	Male	White British
12	16	Female	White British
13	17	Male	White British

resulted in 947 young people receiving computers through a number of youth and community organisations. From each partner organisation, we shortlisted between two and five young people (24 in total) who had agreed to be contacted for research purposes and invited them to participate in an interview. Nine of those approached did not reply to the 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, how their data would be used, and their right to withdraw at any time without affecting any ongoing or future support from the organisation. After the interviews, one young person's data were excluded from analyses due to low language proficiency which made it difficult to understand the questions and respond. A further young person’s data were excluded because the parent often interrupted and the data collected was therefore not reliable.

Demographic information for the thirteen interviewees in the final sample is presented in Table 1. The sample consisted of six females and seven males between the ages of 9 and 22.

Table 2. Themes and sub-themes identified in the interview analyses.

Theme	Sub-theme
'Mismatch between computing and own identities'	Underlying beliefs about 'computer people'
	Self-perception in computing
	Gender conventions in career aspirations
'Understated self-efficacy'	'Holding back'
	Barriers to computing

Around half of the interviewees identified as White British, and all belonged to underserved communities and therefore tended to be from lower socioeconomic backgrounds.

The interviews

Interviews lasted up to 30 minutes and were conducted via video or telephone call, depending on the young person's preference, and all participants under 18 were accompanied by a parent or youth worker from one of our partner organisations. The interviews focused on the young people's self-efficacy and feelings of belonging in computing, the type of people they thought of as 'computer people', and the value of computing for their future careers.

Interviews were conducted and transcribed before the researchers used thematic analysis to search for themes and patterns in the data (Kuckartz, 2014). 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.

Results and discussion

Two main themes were identified across the thirteen interviews, incorporating a number of sub-themes (see Table 2).

Mismatch between computing and own identities

When asked to describe a 'computer person', most of the young people stated that it could be anyone, for example:

"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).

However, the majority also described someone who was highly intelligent, or someone who was nerdy or geeky:

"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).

"Intelligent, logistic, I wouldn't say nerd but. . . No, actually, yes, I would say nerd. Nothing bad about that" (i-1).

Alongside this perception, four of the young people (three of them female) associated a 'computer person' with being male:

"Oh, they're a boy, and they have loads of technology stuff in their house" (i-4).

The view expressed that anyone could be a 'computer person' was therefore often at odds with some more stereotypical ideas amongst the young people, perhaps suggesting a certain level of conflict between a more socially-acceptable view that anyone can achieve anything, and more deep-seated biases about computing as a discipline.

This conflict or mismatch continued to appear in the interviews as we asked about the young people's own abilities in computing and their future career aspirations. Although most of the participants reported that they could be a 'computer person', it was clear that this did not always fit with their interests or their future career choices:

"Well, I don't know. I'm more of a practical person" (i-11).

"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 [sic] 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).

Only two participants wanted to pursue a career within computing, as developers in games and software, both of whom were white males. The female participants were more likely to choose roles in healthcare professions, although one did express an understanding of the value of computing for a future career as an architect: *"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).*

Overall, we found that none of the young people in the current study had a strong identity as a 'computer person', even those who chose CS at school or who were clearly digitally skilled. As in previous research (Wong, 2017), there seemed to be a distinction between doing computing, for instance in school, during leisure time, or for creative things, and being a 'computer person' who would continue to use computing in a future career.

Understated self-efficacy

The second main theme identified across the interviews was a sense of understated self-efficacy: although participants often reported quite a high level of technical competency and engagement with computing, they tended to understate their ability:

"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).

"We have done ICT from Year 7 all the way to Year 10. I think I know what I'm doing" (i-7).

This may be due to an attempt to gain social approval by appearing modest and underplaying their abilities (Luus & Watters, 2012) or perhaps it is a genuine underestimation of their knowledge and skills compared to an idealised version of a stereotypical computer scientist. Given that many of these young people only had access to computers for home use as a result of the Learn at Home campaign, they may also have been comparing themselves to the perceived competence and confidence of their classmates who did have access to computers and, therefore, more experience outside of school (e.g. Gretter et al., 2017).

Several barriers were mentioned to becoming a ‘computer person’, including the need for higher attainment in mathematics, needing to work hard, and needing to *“put my mind to it”*. Another young person explained that computing was just *“not [their] style”*, linking again to a perception of a computing identity that did not reflect their self-perception.

Together, the themes identified in our interviews support the limited previous research with young people from low-income families and provide evidence for the CAPE framework (Fletcher & Warner, 2020) and the Resources and Appropriation Theory (Van Dijk, 2005), highlighting the need to think beyond access to technology when considering the digital divide.

In closing

The theories and research presented in this chapter provide a complex picture of inequality in technology availability and use. This includes several aspects of computing education that contribute to the divide between those from lower- and higher-income families in terms of digital skills and opportunities for study.

Importantly, while access remains a significant factor in maintaining technological inequality, it is clear that providing access to devices and the internet is not enough to create a more equal society in terms of digital skills and participation. Greater efforts need to be made to improve the experience of computing education for young people from a wider range of backgrounds, highlighting the relevance of computing for future careers and breaking down stereotypes around computer science. Supporting families to better understand computing and to develop their own digital skills will also be vital, providing more social connections and role models in computing for young people. Finally, taking an intersectional perspective in both research and practice — considering a broad range of individual factors such as gender, family income, and ethnicity — must be the next step in understanding the digital divide and providing appropriate and relevant computing education.

References

Andrews, J., Robinson, D., & Hutchinson, J. (2017). *Closing the gap? Trends in educational attainment and disadvantage*. Education Policy Institute. https://epi.org.uk/publications-and-research/closing-gap-trends-educational-attainment-disadvantage/.

Archer et al. (2020). ASPIRES 2: Young people's science and career aspirations, age 10-19. https://discovery.ucl.ac.uk/id/eprint/10092041/.

Close the Gap Foundation (2021). *Digital divide*. https://www.closethegapfoundation.org/glossary/digital-divide.

Code.org, CSTA, & ECEP Alliance. (2020). 2020 State of Computer Science Education: Illuminating Disparities. https://advocacy.code.org/stateofcs

Denner, J., Werner, L., Martinez, J., & Bean, S. (2012). Computing goals, values, and expectations: Results from an after-school program for girls. *Journal of Women and Minorities in Science and Engineering,18*, 199–213.

Denner, J., & Campe, S. (2018). Equity and Inclusion in Computer Science Education. In S. Sentance, E. Barendsen, & C. Schulte (Eds.). *Computer science education: Perspectives on teaching and learning in school*, pp. 189-205. Bloomsbury Academic.

Fletcher, C.L. & Warner, J. R., (2020). Summary of the CAPE Framework for Assessing Equity in Computer Science Education. https://www.tacc.utexas.edu/epic/research.

Gretter, S., Yadav, A., Sands, P., & Hambrusch, S. (2019). Equitable learning environments in K-12 computing: Teachers' views on barriers to diversity. *ACM Transactions on Computing Education, 19*, 1-16.

Henrich, J., Heine, S. & Norenzayan, A. (2010). Most people are not WEIRD. *Nature, 466*, 29. https://doi.org/10.1038/466029a

Kemp, P.E.J., Wong, B., & Berry, M.G. (2017). The Roehampton Annual Computing Education Report, 2018. https://www.bcs.org/media/3972/tracer-2017.pdf

Kemp, P.E.J., Wong, B., & Berry, M.G.(2019). Female performance and participation in computer science: a national picture. *ACM Transactions on Computing Education, 20*, 1–28.

Kuckartz, U. (2014). *Qualitative text analysis: A guide to methods, practice and using software*. Sage.

Kunkeler, T., & Leonard, H.C. (2021). Computing skills, beliefs and identities in young people from underserved communities. *RESPECT 2021*, http://respect2021.stcbp.org/2021/05/24/respect-2021-papers/.

Luus, S. & Watters, J.J. (2012). Gifted early adolescents' negotiating identity: A case study of self-presentation theory. *Australasian Journal of Gifted Education, 21*,19–32.

Montacute, R., & Cullinane, C. (2021). Learning in lockdown. https://www.suttontrust.com/our-research/learning-in-lockdown/.

Pantic, K., Clarke-Midura, J., Poole, F., & Allan, V. (2018). Drawing a computer scientist: stereotypical representations or lack of awareness? *Computer Science Education, 28*, 232–254.

Scheerder, A., Van Deursen, A., & Van Dijk, J. (2017). Determinants of internet skills, uses and outcomes. A systematic review of the second-and third-level digital divide. *Telematics and Informatics, 34*, 1607-1624.

Tuckett, S., Robinson, D., & Bunting, F. (2021). Measuring the disadvantage gap in 16-19 education. Education Policy Institute. https://epi.org.uk/publications-and-research/disadvantage-gap-16-19-education/

Van Deursen, A. J., & Van Dijk, J. A. (2019). The first-level digital divide shifts from inequalities in physical access to inequalities in material access. *New Media & Society, 21*, 354-375.

Van Deursen, A. J., Helsper, E. J., & Eynon, R. (2016). Development and validation of the Internet Skills Scale (ISS). *Information, Communication & Society, 19*, 804-823.

Van Dijk, J. (2005). *The deepening divide: Inequality in the information society. Sage.*

Van Dijk, J.A.G.M. (2013). A theory of the digital divide. In M. Ragnedda & G.W. Muschert (Eds.). *The digital divide: The internet and social inequality in international perspective. Routledge.*

Wong, B. (2017). 'I'm good, but not that good': digitally-skilled young people's identity in computing. *Computer Science Education, 26*, 299–317.

Raspberry Pi
Foundation