UNIVERSITY OF CAMBRIDGE

Raspberry Pi Foundation

RASPBERRY PI COMPUTING EDUCATION RESEARCH CENTRE

# Bringing culturally responsive teaching to K–12 computing education

Raspberry Pi Computing Education Research Centre

Department of Computer Science & Technology

University of Cambridge

Project Report (2023)

Supported by Google

# Executive summary

The underrepresentation of certain groups in computing has led to increasing efforts to develop computing education that is responsive and relevant to a more diverse group of learners. The one-year research project described in this report, funded by Google, set out to investigate ways in which computing teachers in the UK could adapt their teaching to be more culturally responsive. It was conducted by researchers at the Raspberry Pi Computing Education Research Centre, a newly formed centre in the Department of Computer Science and Technology, University of Cambridge, UK. Researchers worked closely with a small number of primary and secondary schools to gain an understanding of their current practice, and to support them in planning adaptations to their teaching. The research approach was collaborative and participatory.

To support teachers, we developed a framework of ten areas of opportunity that teachers could consider when deciding how their practice was already or could become culturally responsive. This framework is a valuable contribution to the field that we, and others, will be able to use in broadening this research to larger groups of teachers, both within and outside of the UK.

The research was primarily centred around two workshops held in schools with participating teachers. During the first workshop, teachers worked with researchers to reflect on their current practice using the framework and planned small interventions for their classroom teaching over the coming months. In the second workshop, they reflected on how their classroom practice had evolved with a focus on culturally responsive computing teaching.

The researchers analysed the workshop transcripts and developed four global themes that represent the teachers' experiences. These themes indicate four ways in which schools can develop culturally responsive computing teaching: A) provision of relevant context and content; B) establishment of rapport and confidence building; C) integration of social justice into the computing curriculum; and D) multi-level review of practice. These themes are a second contribution of this research project and align with Bourdieu's concepts of capital and habitus, and Freire's critical pedagogy.

Our research has shown that before and after the intervention, teachers were engaging in a variety of activities that can be categorised under themes A, B and D, with less attention to social justice issues (theme C). Adaptations of context and content (theme A) were constrained by the existence of a prescribed curriculum (the English national curriculum) and existing schemes of work, but our research found that after the intervention, teachers were much more likely to introduce student choice (agency) into their classroom practice to facilitate relevant contexts for a diverse range of learners.

In summary, our research has highlighted four themes that could serve as a basis for a professional development programme for teachers wishing to develop culturally responsive computing teaching. The outputs of the project described here will include three open-access academic papers (subject to being accepted for publication), several blog posts, and a summary report on the Raspberry Pi Computing Education Research Centre's website. There is potential for scaling up the project to reach more teachers, for using the findings to run a professional development (PD) programme, and for conducting a longitudinal mixed-method study relating to the PD programme.

# Table of contents

# Introduction

The objective of the project described in this report was to further our understanding of ways to engage with underrepresented groups in computing. Having developed guidelines on how to use culturally relevant pedagogy in computing as part of our earlier work[1], this project focused on how culturally responsive computing teaching can be implemented in school. In this research project, we worked closely with practitioners to discover how culturally responsive computing teaching can be implemented in the UK, by supporting teachers to plan activities and listening carefully to their experiences in school. Through our research, we hope to highlight the importance of recognising and incorporating cultural diversity in computing teaching and learning in school.

Our study was a clearly defined piece of work with a small number of schools in England, designed to take place over one year, with the intention of seeding a further study which could reach more teachers and schools. Our approach was to work collaboratively with teachers to empower them to reflect critically on their own practice and develop a plan for change that was appropriate for their context. To achieve this, we conducted qualitative research through workshops that took place in person in teachers' schools.

The research questions (RQs) from this small study were:

**RQ1:** How can we frame computing teachers' existing culturally responsive computing teaching practice?

**RQ2:** How are computing teachers able to adapt their current teaching and curriculum to incorporate culturally relevant pedagogy?

**RQ3:** How do teachers express their values and beliefs around culturally responsive computing teaching in the classroom?

In this document, we describe the methods used, the theoretical framework that supported our work and the results to date. The outputs of the project described here will include three open-access academic papers (subject to being accepted for publication), several blog posts and a summary report on the Raspberry Pi Computing Education Research Centre's website.

[1] https://www.raspberrypi.org/blog/culturally-relevant-computing-curriculum-guidelines-for-teachers/

# Theoretical background

In this section, we summarise the theoretical background that drives this study. A longer literature review on culturally relevant pedagogy was published by the team in 2021[2].

## Culturally Relevant Computing

To increase student take-up of computing by a more diverse set of students, attention has been drawn to designing and teaching computing curricula that are culturally relevant and responsive [3,4,5]. Since the 1990s, cultural relevance and responsiveness have been the focus of several key theoretical frameworks in education; for example, Culturally Relevant Pedagogy (CRP)[6], Culturally Responsive Teaching (CRT)[7], and Culturally Sustaining Pedagogy (CSP)[8]. These frameworks highlight the importance of incorporating students' cultures and identities into learning to ensure activities are meaningful with the aim of leading students to academic success.

CRP and CRT have been explored in research in the teaching of computer science. In the USA, Scott et al. developed a framework to create a computing-specific theory, Culturally Responsive Computing (CRC)[5]. CRC notes that digital and technological innovation is achievable for all students and is increased when students are encouraged to reflect on their own identities and cultures. The role of educators is to create a learning context that supports this reflection, that teaches students to understand biases in technological development and also to apply technology in innovative ways to tackle issues that are meaningful to them and their communities[5]. CRC encourages a critical engagement with computing amongst all students, emphasising issues of equity and social justice, and highlighting the important role digital innovation has in addressing these themes[4,5]. CRC can help to counter some learners' early narrow view of a computer scientist[9], which can persist through adolescence, as digitally skilled students do not see themselves as a "computer person"[10]. Research on culturally relevant computing has predominantly focused on teaching and learning in the USA and much less so in the UK[2].

## Cultural Capital

Cultural capital is an important, and often neglected, consideration when developing curricula or resources in education. The term, originating from the work of Pierre Bourdieu, refers to internal aspects of individuals that they share with members of their families and their communities, such as language, knowledge, and belief systems, but also to external products of culture, such as

---

[2] Leonard, H. C., & Sentance, S. (2021). Culturally-relevant and responsive pedagogy in computing: A Quick Scoping Review. *International Journal of Computer Science Education in Schools*, *5*(2), 3–13. https://doi.org/10.21585/ijcses.v5i2.130

[3] Goode, J., Johnson, S. R., & Sundstrom, K. (2020). Disrupting colorblind teacher education in computer science. *Professional Development in Education*, 46(2), 354–367.

[4] Madkins, T. C., Howard, N. R., & Freed, N. (2020). Engaging equity pedagogies in computer science learning environments. *Journal of Computer Science Integration*, 3(2). https://doi.org/10.26716/jcsi.2020.03.2.1

[5] Scott, K. A., Sheridan, K. M., & Clark, K. (2015). Culturally responsive computing: A theory revisited. *Learning, Media and Technology*, 40(4), 412–436. https://doi.org/10.1080/17439884.2014.924966

[6] Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American educational research journal*, 32(3), 465-491. https://doi. org/10.3102/00028312032003465

[7] Gay, G. (2018). Culturally responsive teaching: Theory, research, and practice. teachers college press. https://search.library.wisc.edu/catalog/999890205402121

[8] Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational researcher*, 41(3), 93–97. https://doi.org/10.3102/0013189X12441244

[9] Pantic, K., Clarke-Midura, J., Poole, F., Roller, J., & Allan, V. (2018). Drawing a computer scientist: stereotypical representations or lack of awareness? *Computer Science Education*, 28(3), 232–254. https://doi.org/10.1080/08993408.2018.1533780

[10] Wong, B. (2016). 'I'm good, but not that good': digitally-skilled young people's identity in computing. *Computer Science Education*, 26(4), 299–317. https://doi.org/10.1080/08993408.2017.1292604

artistic expression[11]. Yosso has argued that the culture of dominant groups is that which is most valued in society and becomes the 'norm' by which other cultures or groups are judged[12].

Bourdieu's interpretation of social reproduction theory is framed by key spatial metaphors such as the field, capital and habitus; he posits that institutional structures perpetuate power relations by creating "a system of objective relations which impart their relational properties to individuals whom they pre-exist and survive"[13]. The emphasis on relational properties is critical in examining the institutional loci — especially when applied to micro-contexts such as a computer science classroom. Bourdieu came to identify the three fundamental forms of capital: economic, social, and cultural. Economic capital refers to economic resources and titles that are convertible to money; social capital refers to the existing and potential network of social relationships; and cultural capital can take the form of an embodied, institutionalised, or objective state wherein the dynamics between cognitive competencies (i.e., knowledge) and 'long-lasting dispositions of the mind and body'[11] materialise cultural goods linked to social validation. The interaction of these capitals informs an individual's position in society, determined by the embodied social structures as defined by groups with the most capital.

## Critical Pedagogy

Critical theory calls into question the basic assumptions that people make about the world, and particularly about society and all its institutions, roles and structures. Critical pedagogy is a theoretical concept emanating from the work of Paulo Freire and opens up a space where students should be able to come to terms with their own power as critically engaged citizens[14]. As Henry Giroux writes: "For Freire, pedagogy is not a method or an a priori technique to be imposed on all students but a political and moral practice that provides the knowledge, skills, and social relations that enable students to explore the possibilities of what it means to be critical citizens while expanding and deepening their participation in the promise of a substantive democracy." [11]

The challenge for computer science educators is to support scenarios and learning environments in which their students can participate and become agents of change in their communities. Computer science students who are members of underrepresented minority groups may learn how inequality can be perpetuated in the field, and we believe that the computing classroom itself can become a place of awareness about injustice and resistance to oppression. Our work in this project aims to support the development of guidelines for instructors to reflect upon their roles as enablers of empowerment and change.

The work of Bourdieu and Freire, along with computer-science specific work on culturally relevant computing, gives us a theoretical backdrop with which to frame the work we are setting out to do in schools in the UK, working collaboratively with teachers to ensure that computing classroom teaching is inclusive of a diverse group of learners. Our ultimate goal is not just to broaden representation of learners in computing classrooms, but to empower learners to see the value of computing as a tool for social change alongside gaining confidence and expertise in the subject.

---

[11] Bourdieu, P. (1986). The forms of capital. In: J. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). Greenwood.
[12] Yosso, T.J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race, Ethnicity and Education*, 8(1), 69–91. https://doi.org/10.1080/1361332052000341006
[13] Bourdieu, P. (1977). Cultural Reproduction and Social Reproduction. In J. Karabel, & A. H. Halsey (Eds.), *Power and Ideology in Education* (pp. 487–511). Oxford University Press.
[14] Giroux, H. A. (2010). Rethinking Education as the Practice of Freedom: Paulo Freire and the Promise of Critical Pedagogy. *Policy Futures in Education*, 8(6), 715–721. https://doi.org/10.2304/pfie.2010.8.6.715

# Areas of Opportunity framework

During the study preparation phase, we translated the guidelines into a list of prompts that can be used by educators to review their current computing teaching activities. The prompts were also used to review how teachers adapted their teaching practice once they had been introduced to culturally relevant pedagogy in professional development. We call these prompts the Areas of Opportunity (AOs).

The list of AOs is given in Table 1, with a description of each below.

**Table 1**
*10 Areas of Opportunity (AOs)*

| # | Area of Opportunity | Description |
|---|---|---|
| 1 | Learners | Find out about learners in order to reveal opportunities to adapt our teaching |
| 2 | Teachers | Find out about ourselves as practitioners – to reflect on one's cultural lens |
| 3 | Content | Review what is taught and add in extra culturally relevant content (e.g., about social justice/ethics, data bias accessibility etc.) |
| 4 | Context | Review contexts and examples used – to make teaching relevant, meaningful, to contextualise and make connections |
| 5 | Accessibility | Make the content accessible and relevant |
| 6 | Activity | Provide opportunities for learners to think about user experience and alternate viewpoints, participate in open-ended, inquiry led, or problem-solving activities. |
| 7 | Collaboration | Develop student oriented learning through collaboration and structured group discussion |
| 8 | Student Agency | Develop student oriented learning through student choice |
| 9 | Materials | Review the learning environment (including learning materials) – to increase accessibility, a sense of belonging and promote respect |
| 10 | Policy | Review related policies, process and training in your school and department |

1. **Find out about ourselves.** Within pedagogical content knowledge (PCK) theory, classroom practice can be seen as an enactment of teacher and student knowledge but filtered and amplified by such things as beliefs and orientations[15]. Teachers' ethnicity, religious beliefs, and interests outside of work are likely to contribute to their feelings of belonging and sense of identity in computing, and influence their practice[16], and thus we include this as a key aspect of the development of culturally responsive computing teaching.
2. **Find out about our learners.** The second area of opportunity relates to learners. Students' beliefs, prior knowledge and behaviours also filter and amplify the enacted practice and effect student outcomes. Many aspects of their lives may influence young persons' beliefs about computing, including home factors, youth culture and student interests. Home factors may include heritage culture, religion, and political and economic factors. Culturally

[15] Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK Summit. In *Re-examining pedagogical content knowledge in science education* (pp. 28-42). Routledge. https://doi.org/10.4324/9781315735665-8

[16] Hanover Research. (2020). *Culturally responsive currilcum - research brief and discussion guide*. https://www.wasa-oly.org/WASA/images/WASA/6.0%20Resources/Equity/DISCUSSION%20GUIDE---CULTURALLY%20RESPONSIVE%20CURRICULUM.pdf

responsive teaching often incorporates connections to learners' self-identity, lived experiences and heritage culture through artefacts[17]. A teacher will want to find out whether young people feel "included" or feel that they "belong" in a computing classroom or potentially within a computing career; the student's view may be influenced by their peers' and family's opinions.

3. **Review the lesson content.** The third prompt is to review the content that is to be taught. The specific content that is included in computing lessons should be reviewed to identify content, subject knowledge, and skills that can be added to expand students' culturally relevant view of the world.
4. **Review lesson contexts and examples.** The fourth area of opportunity is to be able to review the contexts that are used to situate teaching activities and the examples that are used to deepen and extend learning. Contexts are the subject areas and topics in which computing activities are situated; for example, in learning to program in primary schools, a teacher might create a history quiz about the Vikings; the context would therefore be the Vikings.
5. **Review the accessibility of the lesson.** The fifth potential action is to reflect on general instructional approaches being used. In England, teachers are required to "adapt teaching to respond to the strengths and needs of all pupils"[18]. Ensuring appropriate pedagogical approaches are used to support all learners to access computing content is likely to be very familiar to teachers through professional development in initial and ongoing teacher training.
6. **Provide opportunities for open-ended activities and solving problems.** The sixth area of opportunity hones in open-ended and problem-solving activities as a way of supporting culturally responsive teaching. Taken in conjunction with consideration of contexts that are relatable to students, teachers might look for opportunities to address social issues impacting both CS and students' community issues.
7. **Provide opportunities for collaboration and structured group discussion.** Further focusing on pedagogy, the seventh prompt relates to student collaboration and how this might be structured. Teachers involved in developing culturally relevant pedagogy guidelines highlighted the importance of collaboration and particularly structured group discussion to facilitate student engagement of those who might be less represented or minority groups in computing
8. **Promote student choice.** The eighth area of opportunity requires educators to consider where they can increase student choice. Self-determination theory[19] highlights the need for student autonomy, competence and relatedness for high levels of self-motivation. In computing lessons, when given the opportunity, students may make different choices according to their interests and personalise their learning to express themselves.
9. **Review the learning materials and environment.** The ninth area of opportunity involves the teacher reviewing the learning materials and learning environment. Common elements in culturally responsive computing learning environments are learning materials that represent students in terms of images and terminology. Such environments enable students to see themselves and their communities within computing. However, finding resources that do not reinforce stereotypes may be challenging.
10. **Review related policies, processes and training in the school.** The tenth and final area of opportunity is at the school level and involves reviewing related policies and processes in the educational context. Without school policies and departmental or year group processes to support teachers' efforts at introducing culturally relevant practices in their computing classroom the task at hand is made more difficult. Teacher education will help educators gain knowledge, skills and confidence to make suggestions for better processes at the school level.

---

[17] Morales-Chicas, J., Castillo, M., Bernal, I., Ramos, P., & Guzman, B. L. (2019). Computing with relevance and purpose: A review of culturally relevant education in computing. *International Journal of Multicultural Education*, 21(1), 125–155. https://doi.org/10.18251/ijme.v21i1.1745

[18] https://www.gov.uk/government/publications/teachers- standards

[19] Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, 55(1), 68.

# Method

The study described here built on prior work conducted in previous years to develop a set of guidelines for computing teachers around developing more culturally responsive practices in the computing classroom[20]. These guidelines were co-developed with teachers and had been published in booklet form[21], but had not yet been implemented in the classroom. The next phase in the research was to investigate how teachers could develop culturally relevant pedagogy in their own classrooms. This took the form of two overlapping and intersecting studies: investigating teachers' existing practice, and an intervention to support teachers to intentionally develop culturally responsive computing teaching activities for their own classroom.

**Table 2**
*Participant Characteristics*

| Case ID | Phase | Gender | Ethnicity | Years of Teaching Experience |
|---|---|---|---|---|
| 1 | Secondary | Female | White or White British and Asian or Asian British | 10 |
| 3 | Secondary | Male | African or African British | 12 |
| 4 | Secondary | Male | Irish | 1 |
| 9 | Secondary | Male | Other White | 10 |
| 10 | Secondary | Male | British, English, Welsh, Scottish or Northern Irish | 13 |
| 11 | Secondary | Male | White British | 12 |
| 12 | Secondary | Female | British, English, Welsh, Scottish or Northern Irish | 12 |
| 13 | Secondary | Female | Indian or Indian British | 17+ |
| 15 | Secondary | Male | Other Asian | 14 |
| 17 | Primary | Female | British, English, Welsh, Scottish or Northern Irish | 10 |
| 18 | Primary | Female | British, English, Welsh, Scottish or Northern Irish | 4 |
| 19 | Secondary | Male | African or African British | 12 |
| 20 | Secondary | Female | African or African British | 6 |
| 21 | Primary | Female | British, English, Welsh, Scottish or Northern Irish | 17+ |
| 22 | Primary | Female | Indian or Indian British | 3 |
| 23 | Primary | Female | British, English, Welsh, Scottish or Northern Irish | 12 |
| 24 | Secondary | Female | British, English, Welsh, Scottish or Northern Irish | 13 |
| 25 | Secondary | Male | African or African British | 1 |
| 26 | Secondary | Male | White or White British and Asian or Asian British | 2 |

## Data collection

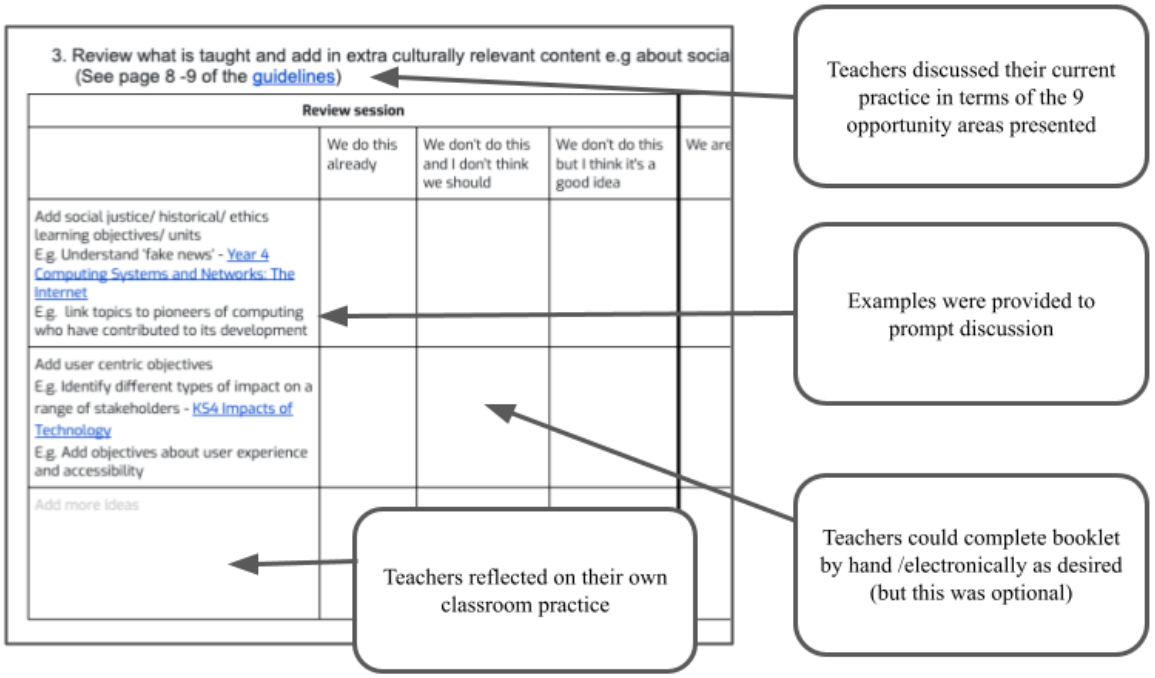
We facilitated two workshops per school with a) data collection on current practice and planning for the experimental phase (i.e., post-intervention) and b) data collection on the changes that

[20] Leonard, H. C., Kirby, D., Sentance, S., Chinaka, L., Deutsch, M., Dimitriadi, Y., & Goode, J. (2021). Localising culturally responsive computing teaching to an English context: developing teacher guidelines. In *Understanding Computing Education (Vol 2): Equity, Diversity and Inclusion. Proceedings of the Raspberry Pi Foundation Research Seminars* (pp. 56-62). rpf.io/seminar-proceedings-vol-2-leonard-et-al

[21] https://static.raspberrypi.org/files/research/Guide+to+culturally+relevant+and+responsive+computing+in+the+classroom.pdf

occurred during the experimental phase. The workshops were recorded by audiotape and transcribed, which was then used as the basis for thematic analysis. Attrition is to be expected with a study that requires considerable commitment from schools and teachers: while 26 teachers from 10 schools started the project, 19 from 9 schools participated in Workshop 1, with 17 from 8 schools completing the project. By using a small sample, the researchers were able to derive thick descriptions of what occurs in their classrooms and their perceptions of such practices. Furthermore, the open-ended, dialogic approach enabled teacher agency in selecting the opportunity area they wished to focus on. Researchers made field notes and also collected pre-workshop booklets (see Figure 1) on teachers' initial thoughts, current practices and supplementary information about their school/teaching (e.g., experience level). Demographic data relating to the participants is shown in Table 2. All data was anonymised at source and ethical procedures for qualitative research were strictly adhered to.

**Figure 1**
*Extract of booklet for Workshop 1*




## Data analysis

Workshop data were transcribed professionally, with qualitative data analysis (QDA) software used to aid with categorisation and analysis.

The Workshop 1 data were coded iteratively with an inductive-deductive approach to the initial coding cycle. The top-level (deductive) codes were taken from the Areas of Opportunity framework and inductive coding used to develop new codes representing the content of the workshop discussion and teachers' experiences. Cycles of coding ensured that the final set of codes had removed duplicate coding.

The Workshop 2 data were coded deductively using the coding framework established for the Workshop data. For both sets of data, two researchers were involved in the coding process and carried out inter-reliability tests to ensure that their coding was aligned. Thematic analysis was used to derive broad themes from the codes and subcodes.

# Results

In this section, we show how the AOs enabled teachers to both review their existing practice and plan and implement small interventions. From the analysis of the two workshops, we generated the following sub-themes emerging from the Areas of Opportunity framework. The full codebook is lengthy, so Table 3 shows only the first level subcodes for each AO shown in Table 3. Additional top-level codes were added for barriers, careers, parental influence and gender to capture teachers' comments on these aspects, which we will explore in a future study.

**Table 3**
*Coding scheme for Workshop 1 and Workshop 2 data*

| Codes | | Codes | |
|---|---|---|---|
| 01 Learners | | 06 Teaching_Activity | |
| | Locality | | Impact of CS_Social Justice |
| | Rapport | | Representing the Self |
| | Monitoring and System Reports | | User Experience Design |
| 02 Teachers | | 07 Collaboration | Collaboration |
| | Experience Level | 08 Student Agency | Agency |
| | Reflexivity | 09 Materials | |
| | Teaching Philosophy | | Bias |
| 03 Content Review | | | Classroom Environment |
| | Reviewing Practice | | Models and Frameworks |
| | Matching Students' Interests | | Software and Programs |
| 04 Context | | 10 School | |
| | Changing the Context | | Events |
| | Industry Exposure and Learning Outside the Classroom (LOtC) | | School Structure |
| 05 Accessibility and Relevance | | | Policy and Practice |
| | Additional Support for Students | | Ethos and Environment |
| | Accessibility | | |

## Analysis of coding

Using these sub-codes we conducted a frequency analysis of data collected before and after the intervention. Table 4 shows that in terms of their current practice, teachers reflected on establishing rapport with learners and increasing the accessibility of their lessons. After the intervention, the most common mentions were changing the context of lessons and student agency. In addition teachers discussed the following areas more frequently than prior to the intervention:, reflexive teaching, the classroom environment, collaboration and representation of the self.

**Table 4**
*Frequency of subcodes (inductive): change from Workshop 1 to Workshop 2*

| Teachers' current practice - most frequently mentioned topics | | | Post intervention - most frequently mentioned topics | | | ↑↓→ |
|---|---|---|---|---|---|---|
| Subcode | Num Refs | AO name | Subcode | Num Refs | AO name | |
| Rapport | 242 | Learners | Changing the Context | 196 | Context | ↑ |
| Accessibility | 157 | Accessibility and Relevance | Agency | 157 | Student Agency | ↑ |
| Monitoring and System Reports | 143 | Learners | Reflexivity | 125 | Teachers | ↑ |
| Changing the context | 138 | Context | Classroom environment | 80 | Materials | ↑ |
| Reviewing teaching practice | 120 | Content | Reviewing teaching practice | 76 | Content | ↓ |
| Impact/social justice | 73 | Teaching Activity | Collaboration | 66 | Collaboration | ↑ |
| Reflexivity | 68 | Teachers | Representing the Self | 60 | Teaching Activity | ↑ |
| Agency | 60 | Student Agency | Impact/social justice | 53 | Teaching Activity | ↓ |

## Establishing rapport with students

Teachers in Workshop 1 talked frequently about talking to students about their background and interests as part of establishing a rapport and understanding them better:

*"And how it relates to what their parents and carers might do, does that direct what they do? If your parents or carers are in computing, does that mean you want to do computing? Or if your parent or carer is a doctor, does that mean you want to take up science?"* (Teacher 10, Workshop 1)

Understanding students' needs and interests on an interpersonal level enables teachers to engage with more comprehensive models of learning, incorporating social and cultural aspects of the learning process in their approaches to education and more specifically, computing education[22]. The significance of establishing rapport can be accredited to its perceived impact when providing culturally relevant contexts and content.

## Adapting the context

All teachers discussed changing the context of the lesson to adapt to students' interests and other learning, both prior to and after the lesson. For example, Teacher 21 states that knowing her students has led to her changing the unit context to fit with teaching in other subjects:

[22] Nolan, K., & Tupper, J. (2016). Thinking with theory in teacher education: Cultivating critical capacities through Bourdieu's social field theory. *Teacher Capacities: Knowledge, Beliefs and Skills*, 214.

*"I would say in computing, yes, I am changing the context, because I'm linking it to what else is happening in class […] with the music one in Year 2, we didn't just [...] create animal music, we created music for a poem that they were doing in English. So we've changed it like that. The data handling one, we're not just collecting random data on colours which is what NCC suggests. We're collecting data about the number of teaspoons of sugar in different foods, because that all links to our science classes."* (Teacher 21, Workshop 1)

Teachers feel that adapting the context to make it relevant across the curriculum helps computing feel more relevant.

### Student agency

After the intervention, many of the teachers reported that they had developed student agency or choice as a way of making computing more relevant to them in terms of their identity:

"*So the avatar is a white boy, and so all the students immediately began to change it. Minecraft do have different characters there, male and female, a whole range there. So they were able to customise that and feel a bit of ownership over the character looking more like them.*" (Teacher 10, Workshop 2)

And the teacher then reflects on why he lets the children change the avatar, when he is most concerned about them learning the programming aspects of the lesson:

"*Why did I let them change it? I think it's only when they asked and I saw this big character in front of me that was a white, I thought, okay, hang on a minute, that's actually a good idea to do. Because when you then go onto the [Minecraft] world and they're all looking at each other, what you don't want is 30 white male characters walking around on Minecraft as opposed to everyone's got their thing.*"

### Reflexivity on practice

Many of the teachers reflected on what they had changed in their practice since taking part in the project, and there were a number of comments about raising their consciousness of their own practice, for example:

"*[I've] not found out about myself, but improved my thinking around being careful about bias, trying to consider the feelings and emotions of other people and their experiences, like [anonymised], for example. And making sure that I give them a well-rounded, unbiased set of examples that don't encompass one political viewpoint.*" (Teacher 24, Workshop 2)

The above gives just a snapshot of the analysis of coding, more detail is being reported in the research papers being written relating to this project.

## Themes underpinning culturally responsive computing teaching

As part of the analysis, we have identified **four themes** that provide an interpretation for the coded data. We can use these to categorise computing teachers' practices relating to culturally responsive teaching:

A. Provision of relevant context and content
B. Establishment of rapport and confidence building
C. Integration of social justice concepts (e.g., data bias, ethics of emerging technologies) into the computing education curriculum
D. Multi-level review of practice

These themes align with Bourdieu's concepts of capital and habitus (themes A and B), and Freire's critical pedagogy (themes C and D). Themes A and B are about the learner's context, culture and

background, and what the teacher can do to support the development of digital cultural capital. Themes C and D are about the need for computing education to actively strive for a more socially just world, and value dialogue, discussion and questioning. Through theme C, pupils and teachers are encouraged to both consciously attend to social injustice that might be brought about through use of technology, and embrace computing as a tool for advancing equity and freedom in the world. Theme D relates to the ways in which teachers and schools can actively critique their practice and pedagogy, and the impact it has on making computing more diverse and inclusive.

Mapping the coding scheme to the themes shows that before and after the intervention, teachers were actively engaging in a variety of activities that can be categorised under themes A, B and D, with less attention to social justice issues (theme C). Adaptations of context and content (theme A) were constrained by the existence of a prescribed curriculum (the English national curriculum) and existing schemes of work, but our research found that after the intervention, teachers were much more likely to introduce student choice (agency) into their classroom practice, and to facilitate relevant contexts for a diverse range of learners. Our conclusion is that more input will be needed to support computing teachers to consider the impact of computer science on social justice issues, at least in the UK.

Some examples of the ways in which teachers' experiences can reflect our themes are shown in Table 6.

**Table 6**

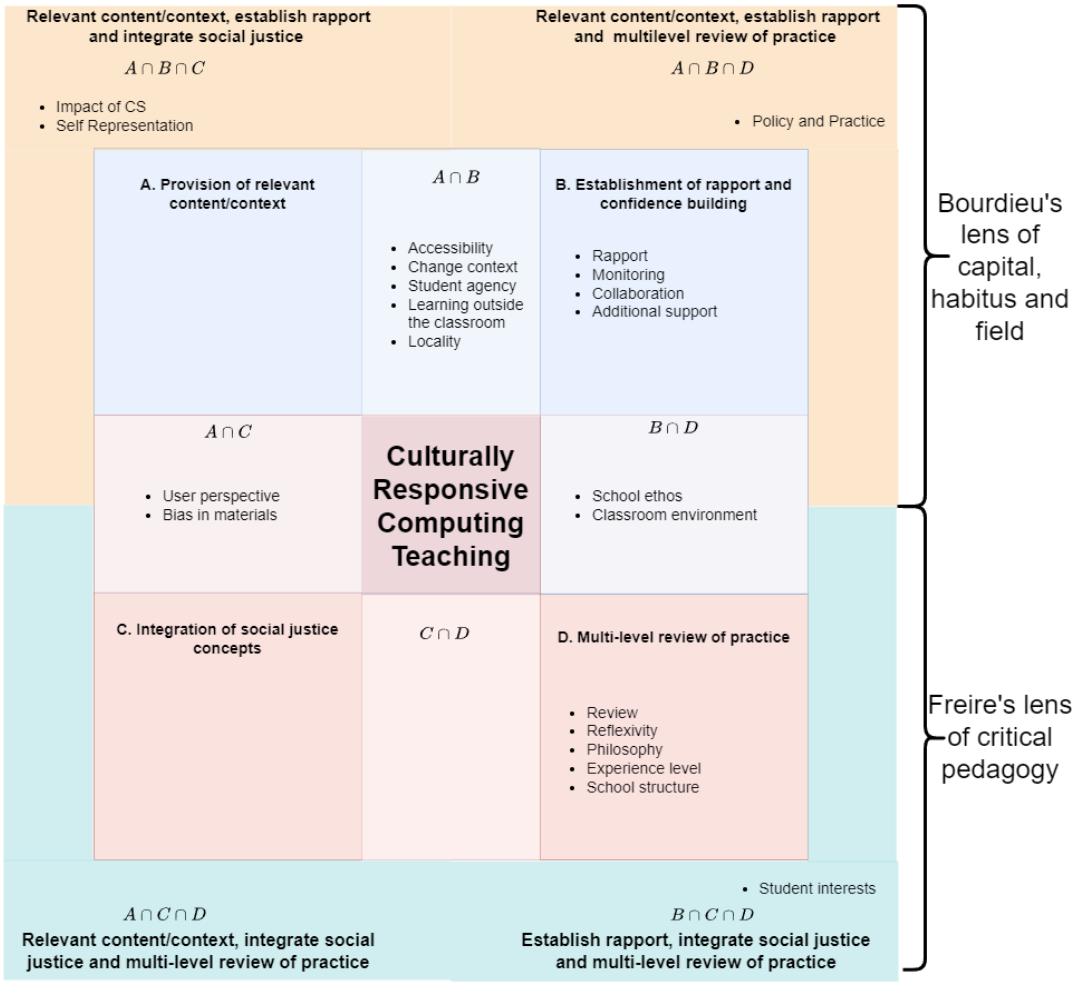
*Examples of themes for culturally responsive computing teaching*

| Theme (s) | Example |
|---|---|
| A: Provision of relevant context and content | *"So in my following lesson, I mentioned about a particular character who was an army general. He was an administrator for NASA, and he actually went to the International Space Station, I think, four times. I think his name was…. Charlie Bolden. And he is someone from Afro-Caribbean, black background. And he went up on to the International Space Station. I said, look, people from all cultures from different backgrounds, male and female, go and are involved in technology."* (Teacher 11, Workshop 2) |
| B: Establishment of rapport and confidence building | *"When we're in lessons we'll talk about the work with them individually. So I'll go around and scan the room, and say, right, how are you getting on with the work, are you struggling with this, how do you feel about it? And the same with parents' evening. You know, we'll open the question up and I'll always tend to ask the students, how are you finding computer science? And at that point, obviously, the hope is if they're not enjoying it or if they're feeling excluded, then that normally comes out then."* (Teacher 15, Workshop 1) |
| C: Integration of social justice concepts (e.g., data bias, ethics of emerging technologies) into the computing education curriculum | *"So one of the activities that we do is our digital literacy unit, whereby we look at social media, and how things are posted on social media. And we draw in some popular figures and how it's impacted them. So, for example, Kevin Hart, and how he posted something on Twitter a long time ago, and how it came back to impact him."* (Teacher 10, Workshop 1) |
| D: Multi-level review of practice | *"What I try and do is I try and make sure that I'm, well for me personally, I try and make sure that I'm keeping up to speed with things nationally, internationally, and the impacts. So using* |

| | |
|---|---|
| | *things like social media to try and keep abreast of what other teachers are doing. Also following other things outside my own curriculum, so looking at different people through things like Twitter, so Jeffrey Boakye. And also reading around different genres. So trying to educate myself with different writers, so Bernadine Evaristo."* (Teacher 1, Workshop 1) |

Figure 3 shows how the four themes have been drawn from the coding of the teachers' views and experiences, and shows that most of the codes can be categorised as more than one theme. For example, self representation, that is, seeing yourself reflected in the computing curriculum, materials and the ecosystem, relates to themes A, B and C. These themes align to the sociological lenses we have been using to understand culturally relevant computing teaching in the classroom.

**Figure 3**
*Themes for developing culturally responsive computing teaching*



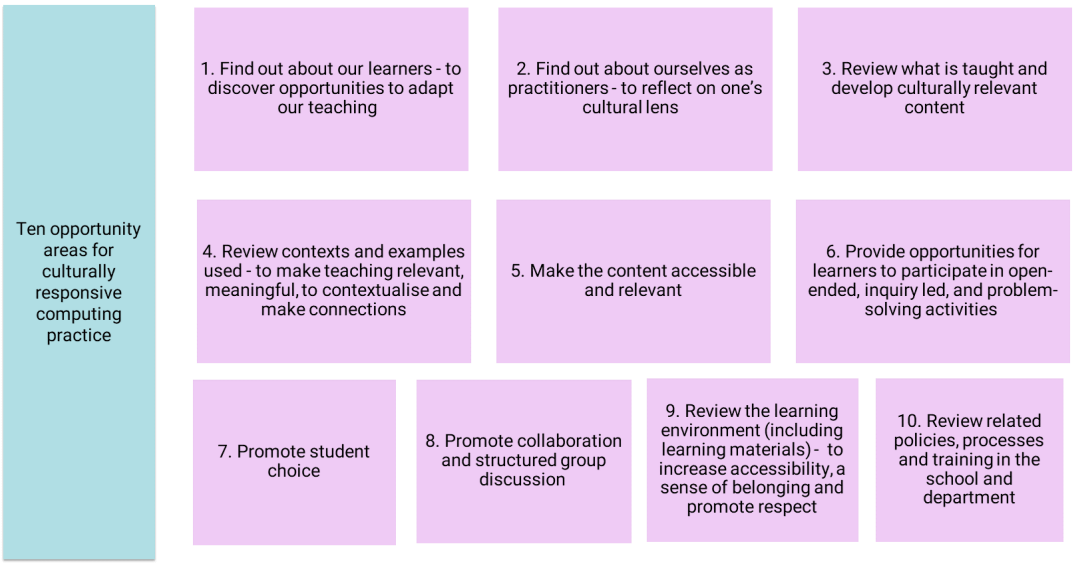
# Conclusion and further work

Through this research we have supported a small number of teachers in developing their culturally responsive computing teaching practice, but at the same time have made two contributions that could feed into further research work.

1. The Areas of Opportunity framework (see Figure 3) provides prompts for schools and teachers when developing culturally responsive computing practice. It can be used to develop professional development for teachers around culturally responsive computing, wherever they are in the world, in the form of reflective prompts to be used in lesson and curriculum design.

2. Our burgeoning understanding of the four key themes, underpinned by sociological theory, can be used to explain teachers' beliefs and practice relating to culturally responsive computing teaching and makes a contribution to the field of CRC. These themes indicate four ways in which schools can develop culturally responsive computing teaching: A) provision of relevant context and content; B) establishment of rapport and confidence building; C) integration of social justice into the computing curriculum; and D) multi-level review of practice. These themes are a second contribution of this research project, and align with Bourdieu's concepts of capital and habitus, and Freire's critical pedagogy.

***Figure 3***
*The AO Framework*




Overall, the mapping of the data analysis to our themes shows that while teachers feel confident to adapt lessons along the lines of themes A, B and D, there is less evidence that schools and teachers are engaging in activities relating to theme C. The lack of integration of content related to social justice in computing lessons is a significant issue, which may be England-specific but worthy of investigation in other countries. Further, this issue is increasingly relevant everywhere as machine learning becomes more pervasive in society.

## Further work

Further research is needed to corroborate the four themes to identify what might be missing, and whether they fully represent teachers' experience of culturally responsive computing teaching. This could take the form of a more longitudinal study with a larger sample of computing teachers, using a mixed-methods approach (collecting both quantitative and qualitative data). The four themes could also be used as modules for a professional development programme that engages teachers specifically with their own development to understand ways of adapting their own practice. The research could focus on the development of materials that embody some of the ideas developed through this project, and teachers' experiences using and adapting the materials could be investigated. Finally, we need to understand more of the learners' experiences and perceptions of computing to tackle some of the systemic and structural challenges around underrepresentation. This could particularly focus on theme C, to investigate how young people, with the support of teachers, can be empowered through computing to challenge issues of social justice and inequity.

# Acknowledgements

We are very grateful to Google for the $69K donation to the Raspberry Pi Computing Education Research Centre that has enabled us to work on this project, and to the Raspberry Pi Foundation for some administrative support.

# Project Team

Sue Sentance, University of Cambridge
Katharine Childs, Raspberry Pi Foundation
Lynda Chinaka, Roehampton University
Anjali Das, University of Cambridge
Alyson Hwang, University of Cambridge
Jane Waite, Raspberry Pi Foundation

The Raspberry Pi Computing Education Research Centre is part of the Department of Computer Science and Technology at the University of Cambridge. It's a joint initiative between the University of Cambridge and the Raspberry Pi Foundation. The primary aim of the Centre is to investigate how to engage all young people in computing, computer science, and associated subjects. Our focus is on collaborative work with schools and educators to ensure that research can readily inform practice. For more information, visit our website at http://computingeducationresearch.org

***To cite this report:***

*Raspberry Pi Computing Education Research Centre (2023). Bringing culturally responsive teaching to K-12 computing education. Project Report. Available at: http://computingeducationresearch.org/crp_report_2023*