# Funds of identity and culturally responsive computing: K-5 teachers' adaptations to computing resources

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## ABSTRACT

Although computing is increasingly taught to K–5 students, females and certain ethnic groups are underrepresented in examinations and careers. Disparities have been attributed to students feeling a disconnect between their identities and the computing stereotype. Culturally responsive teaching has been used in the US to adapt resources to start to address these disparities, but less so in England, particularly for K-5 classroom contexts. This study investigates the ways in which K-5 teachers in England adapt existing computing teaching resources to be more culturally responsive. Building on ten culturally responsive teaching prompts (called Areas of Opportunity (AOs)) and a sociocultural identity theory, funds of identity (FoI), we ask RQ1: *In what ways do K-5 teachers collaboratively adapt resources to deliver culturally responsive computing teaching?* and RQ2: *What does a funds of identity analysis reveal about computing resource adaptations?*

Researchers and 12 teachers collaboratively adapted a set of computing lessons. Interviews were conducted with the teachers post-lesson delivery, and thematically analysed to identify seven culturally responsive adaptation themes. Teachers reported that students drew most on practical funds of identity (e.g., football, drawing), but support was needed, e.g., discovering lower socioeconomic background students' hobbies.

Teacher adaptations aligned with other culturally responsive resources and all ten AOs were useful for identifying potential adaptations. But a prompt to foster community development was found to be missing. The significant contribution from this study is to introduce FoI, not used before in our context. We suggest FoI provides a nuanced view of identity that may be useful to teachers, resource developers, and researchers to reduce identity disparities in computing.

## CCS CONCEPTS

• **Social and professional topics → K-12 education**; **Race and ethnicity**; **Women**.

## KEYWORDS

K-12, education, culturally responsive teaching, student identity

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## 1 INTRODUCTION

Throughout the world, countries are incorporating computing into formal education and curricula [13, 44]. For example, computing is a mandatory subject for all students aged 5 to 14 years in England. However, when students select subjects for formal qualifications from the age of 15 onwards, exam entry data shows a lack of diversity amongst candidates, with female students and students from certain ethnic groups underrepresented [21, 42]. The situation is similarly unbalanced in the workplace (e.g. [3, 4]), with recognition by government that more action is needed to drive change [37].

Equity pedagogies such as culturally relevant pedagogy [23] and culturally responsive teaching [16] have been shown to increase engagement and achievement amongst diverse groups of learners. In culturally responsive computing teaching, learners' identities are affirmed because activities value their interests and heritage [25, 39]. Previous work has synthesised the principles and objectives of culturally responsive computing curriculum resources (e.g.[27, 28]) and in the US, curriculum designers have used these to develop culturally relevant curricula (e.g.[15]). However, teachers may choose to adapt existing computing resources to be culturally responsive rather than searching for materials that have been designed specifically to be so. Professional development activities can increase teachers' confidence to make these adaptations [24] but investigation into what types of adaptation teachers will make has yet to be done.

This study contributes to research into culturally responsive computing teaching in two ways. Firstly, this study is one of the first to explore how teachers take **existing** K-5 (students aged 5 to 11 years old) computing resources and **adapt** them to be culturally responsive in the context of the English curriculum. Secondly, we draw on Vygotsky's concept of *perezhivanie* - or lived experiences - to frame learners' identities in a sociocultural context [45]. We do this by introducing and using *funds of identity* (see Figure 1), a framework not yet explored in the context of K-5 computing resource adaptations, as a lens to analyse teachers' descriptions of student artefacts.

Our research questions are **RQ1: In what ways do K-5 teachers collaboratively adapt resources to deliver culturally responsive computing teaching?** and **RQ2: What does a funds of identity analysis reveal about computing resource adaptations?**

# 2 BACKGROUND AND LITERATURE

## 2.1 Equity pedagogies and culturally responsive computing teaching

Equity-based pedagogies have become more prominent in education in recent decades, through, for example, the academic scholarship of authors from historically marginalised groups [16, 23]. Culturally relevant and responsive frameworks use a definition of equity that seeks to connect the lived experiences, backgrounds, and cultures of underrepresented racial and ethnic groups with high expectations for student learning and skills development [23]. As these theories have been applied to computing, the focus has widened to take a sociocultural approach and recognise that the negative effects of minoritisation may be multiplied at the intersections of race, gender, special educational needs, and social class [18, 27, 38]. Two small-scale research studies showed the potential for culturally responsive approaches in computing education. The COMPUGIRLS program found that by integrating technology with culturally relevant themes, minoritised adolescent girls became more interested in technology-related fields and showed increased critical thinking skills [40]. A longitudinal follow-up study highlighted sustained positive outcomes on participants' academic engagement and aspirations in STEM fields [39]. The principles of culturally responsive teaching have been found to align broadly with Universal Design for Learning, another framework for designing learning that should appeal to all learners [22].

In England, work to localise culturally responsive computing teaching (CRCT) is taking place in the context of an educational system that supports multiculturalism [24]. Diversity is celebrated as a strength, and mutual respect for all individuals and their cultural background is promoted in schools [8].

A set of ten Areas of Opportunity (AOs) has operationalised how computing teachers can be culturally responsive in reviewing their practice [46] and are summarised in Table 1. These AOs have been successfully used to describe general **existing** culturally responsive practices of English primary (K-5) and secondary computing teachers *(n=26)*, namely that teachers make computing accessible for students, use monitoring and system reports to learn about their students' culture, change the context of their lessons to better reflect students' interests, and build rapport with students, including understanding students' background and identity [19]. However, a detailed investigation into how a specific set of resources might be **adapted** in the English context has not yet been conducted. Adapting resources has been explored in the US. For example, a study of 5th- to 8th-grade (primary and middle school) teachers found they needed practical and cognitive scaffolds to overcome challenges around time, preserving learning objectives and meeting personalisation goals to customise a Scratch curriculum [43].

## 2.2 Identity in computing

A deeper understanding of identity theory in K–12 computing education is important as it is considered to have the potential to attract more diverse groups of students to the subject [35]. Sociocultural theorists argue that aspects of identity such as race and gender are dynamic and fluid, and constantly negotiated and redefined through social experiences and relationships [17]. In particular, Vygotsky's concept of *perezhivanie* expresses the idea of identity as subjective, based on how each individual's lived experiences contribute towards their interpretation of culture and society [45]. Culturally responsive computing calls for both classroom technologies and learning experiences to reflect and build upon minoritised students' identities [39, 40]. Allowing learners to express themselves [27] and explore their identity [20] are important features of equitable learning experiences because they legitimise students' sociocultural identities as assets to support learning [14]. Previous research in computing has shown that culturally responsive learning experiences can positively impact students' identities [35]. For example, a qualitative study found that secondary-aged students *(n=32)* in England describe the identity of computing workers as clever but antisocial [48]. Most recently, a longitudinal 14-year study of STEM capital, with 47,000 young people in England found that students from diverse backgrounds are less likely to continue studying computing because they perceive a disconnect between their identity and the stereotypical identity associated with computing [1].

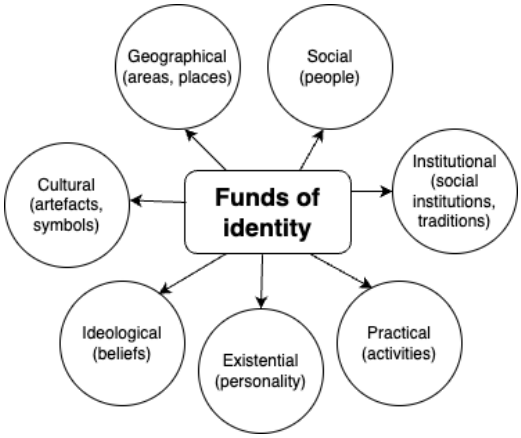


**Figure 1: Funds of identity framework (as suggested by Poole (2017) [31] of five types from Esteban-Guitart and Moll (2014) and two types (ideological and existential) from Poole (2017))**

## 2.3 Funds of identity

A framework that has been used to explore identity is the funds of identity framework. At the intersection of education, culture, and psychology, the concept of funds of identity (FoI) has been defined as "historically accumulated, culturally developed, and socially distributed resources that are essential for people's self-definition, self-expression, and self-understanding" [12, p. 37]. Employing a FoI framework in teaching and learning means that students use their imagination, agency, and creativity to connect what they know to who they are in an ongoing way [10]. Five different types are proposed: 1) geographical, 2) practical, 3) cultural, 4) social, and 5) institutional [12]. Students' FoI are detected by the creation of identity artefacts such as self-portraits [12] or identity projects that build up a wider depiction of a students' interests, attributes, families and future goals [14]. A study in China confirmed that students from diverse cultural backgrounds exhibited Esteban-Guitart and

**Table 1: The ten Areas of Opportunity Prompts for reviewing, creating and adapting computing lessons**

| # | 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 in terms of the content; add in extra culturally relevant content (e.g., about social justice/ethics, data bias, user aspects 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 for all learners |
| 6 | Activity | Provide opportunities for learners to 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 |

Moll's five FoI and proposed two additional FoI types: 6) ideological, and 7) existential [31] (Figure 1).

Wofford and Gutzwa hypothesised, in the theory of funds of science identity, that FoI theory can be mobilised to deliver equitable STEM education by incorporating students' lived experiences in science activities, creating classrooms that are identity-affirming spaces, and identifying and accounting for how structures of power have historically shaped course content and contexts [47]. The body of literature developing FoI as a theoretical framework continues to grow, with the suggestion that existing power asymmetries in education may result in students from underrepresented backgrounds feeling that their FoI are invisible in the classroom [11].

Funds of identity has its roots in funds of knowledge theory. Funds of knowledge considers the skills, knowledge and beliefs in students' families and communities as valuable educational resources [16] to address equity issues in STEM education [7], and has been used to explain how adolescents interpret algorithmic fairness in computing [36]. However, critics argue that building connections with families and communities to identify funds of knowledge is time-consuming for teachers[26] and call attention to the fact that students also create funds of knowledge outside their homes through a variety of life experiences [31]. In our study, our focus is on funds of identity, not funds of knowledge.

## 3 METHODOLOGY

This paper reports on the second and third phases of a research study, with ethical approval obtained according to BERA (British Educational Research Association) guidelines [5], to collect and analyse data for the entire study, including analysing student artefacts. The first phase of the study was the professional development elements of a one-day workshop introducing participants to culturally responsive computing teaching. This phase has been separately reported on [24]. In subsequent phases, teachers and researchers co-designed adaptations to a set of existing learning resources, and teachers delivered the adapted resources in their computing lessons.

### 3.1 Participants

Thirteen K-5 teachers were recruited to take part in the overall study using a range of local and national teacher networks. Teachers were eligible for selection if they taught computing to Grade 3 or 4 students and had permission to take part in the study from their headteacher. Following phase one, one teacher became ineligible to take part in further phases due to no longer having a teaching role. Therefore, 12 teachers took part in the resource adaptation and delivery; 10 identified as female and 2 as male (see Table 2). 8 participants identified as White British, and 4 were from other ethnic groups. The ratio of genders and of White British participants to other ethnicities is in keeping with national averages [9]. Five specialist computing teachers took part, which is perhaps higher than expected for a K-5 context [41].

11 schools, 10 in urban settings and 1 in a rural area took part in the study. Teachers 202 and 204 worked at the same school. Schools were distributed geographically across England: 5 in London, 4 in the South East, 2 in the East of England, and 1 in the North West of England. Teachers could choose one of two units of work to adapt (Section 3.2) and also whether these resources would be delivered to Grade 3 students (aged 8 to 9 years old) or Grade 4 students (aged 9 to 10 years old). These choices were based on the teacher's planned teaching activities for the next term and each teacher's judgment of their students' knowledge and skills.

### 3.2 Units of work to be adapted

The research team selected two units of work for adaptation from an entire set of national K-12 computing lessons and learning activities [32] using the following criteria: i) The unit did not require extra hardware or specialist software; ii) The unit did not include programming activities, as 70% of K-5 teachers in the UK are non-specialist computing teachers [41] and the focus here was to investigate opportunities for adaptation, rather than become embroiled in professional development on programming; iii) The activities in the unit offered scope to be adapted to different contexts.

**Table 2: Groups and their participants who worked on the adaptation designs together (Roles: CT - class teacher, SP - specialist computing teacher, R - researcher) (Gender: F - female, M - male) (*self-identified)**

| Group | Participant | Role | Age range | Gender* | Ethnicity* |
|---|---|---|---|---|---|
| Image Editing Group A | T101 | CT | 45 - 54 | F | White British |
| | T102 | CT | 35 - 44 | F | White British |
| | Res 4 | R | 25 - 34 | M | White Irish |
| Image Editing Group B | T201 | CT | 25 - 34 | F | White British |
| | T202 | CT | 18 - 24 | F | White British |
| | T203 | SP CT | 45 - 54 | F | White British |
| | T204 | CT | 25 - 34 | M | White British |
| | Res 1 | R | 35 - 44 | F | White British |
| Vector Graphics Group C | T301 | SP CT | 35 - 44 | F | Irish |
| | T302 | SP CT | 25 - 34 | F | White British |
| | T303 | CT | 45 - 54 | F | Indian |
| | Res 2 | R | 45 - 54 | F | White British |
| | Res 5 | R | 45 - 54 | F | Black British |
| Vector Graphics Group D | T401 | SP CT | 35 - 44 | F | White British |
| | T402 | SP CT | 45 - 54 | M | British Chinese |
| | T403 | CT | 25 - 34 | F | Arabian |
| | Res 3 | R | 55 - 64 | F | White British |

The two units selected were from the image manipulation and representation strand of computing (referred to as image representation in this paper) and comprised six one-hour lessons that developed students' computational thinking skills in areas such as pattern recognition, decomposition and problem-solving. In the Image Editing unit, students learned to edit and save digital images, and explored the impact of these changes. In the Vector Graphics unit, students used drawing tools to form shapes and lines to make vector drawings. They moved onto layering, grouping and duplicating objects to create more complex drawings. The recommended pedagogical approach was for teachers to model the concepts and skills to aid students' understanding.

## 3.3 How resources were adapted

We facilitated the co-design resource adaptation process during an in-person workshop, during online monthly meetings, and through an iterative online process of sharing and reviewing of resources with teachers over a period of 4 months. In curriculum co-design, teachers, researchers and developers work together to co-design, develop, and test innovations to curriculum materials [29].

*3.3.1 Workshop.* Teachers attended an in-person day-long workshop in November 2022 [24]. At the workshop, researchers began by delivering professional development (PD) on culturally responsive computing teaching to the whole group of teachers. PD presentation material is available on the project website [33]. The funds of identity framework was not introduced to teachers during the workshop, but the concept of identity was raised in several ways. Firstly, in order for them to reflect on what shaped their own teaching practice, teachers were asked the question "What affects your cultural identity?". In a subsequent activity, we asked teachers to suggest practical ways that they found out about their students' identities.

In the middle part of the day, teachers worked in four self-selected groups (see Table 2) to start to suggest adaptations of resources. One or two researchers facilitated each group to examine the resources and use the Areas of Opportunity [46] to identify potential culturally responsive adaptations, which were added to a working wall. In the final workshop activity, each group synthesised the ideas from their own working wall into a verbal design plan which gave detailed information about how the existing lessons were to be modified so that they were context-specific and relevant to the students in participating schools.

*3.3.2 Development.* The existing resources contained lesson plans, presentations and worksheets, which all needed to be adapted in line with each group's verbal design plan. As K-5 teachers have been found to lack time to write or modify resources [30], the changes were applied to the resources by three researchers acting as resource developers. The researchers had been K-5 teachers, and all had researched and published on K-5 computing education. The resulting amendments were shared with participating teachers through shared online files. Each group met online in December and January 2022 so that teachers could provide feedback about the amendments and further suggestions for iterative improvements, which were again applied by the researchers and checked by the teachers. The adapted versions of the resources were shared with teachers in February 2023.

*3.3.3 Delivery and final refinements.* Once teachers received the adapted lessons, they could then make further refinements to the materials before and during delivery in class. The Image Editing resources (Groups A and B) were delivered to four classes of Grade 3 children and four Grade 4 classes, some 250 students. The Vector Graphics resources (Groups C and D) were delivered to seven classes of Grade 4 children, and one mixed Grade 3 and 4 after-school club, some 200 students. All classes included 25 to 32 students; the after-school club had 20 students.

## 3.4 Data collection and analysis

Five sources of data were collected and analysed. Firstly, researchers made field notes of the teachers' suggested adaptations throughout the study. Secondly, during the workshop, each group presented a verbal summary of their design plan, and these were audio recorded and transcribed. Thirdly, teachers shared their annotated lesson plans with details of any refinements made during lesson delivery. Fourthly, teachers provided some examples of student work. Fifthly, after the lesson delivery of the adapted resources, each teacher took part in a semi-structured online interview to reflect on their adaptations. Interviews lasted between 30 and 75 minutes. The semi-structured interviews included questions such as what changes the teachers made to the resources and why these were made. Interview questions and the adapted resources are available on the project website [33]. Qualitative data from this study is not being published because comments from participants, although anonymised, could

**Table 3: Resource adaptation themes**

| | Themes | Cases # (n=12) | Segments# |
|---|---|---|---|
| 1 | Adding open-ended application of skills | 12 | 182 |
| 2 | Discussing social, ethical or cultural issues | 12 | 173 |
| 3 | Amending or adding examples for relevance | 9 | 31 |
| 4 | Introducing technical vocabulary | 8 | 32 |
| 5 | Encouraging independent experimentation | 8 | 24 |
| 6 | Introducing more group activities | 5 | 15 |
| 7 | Showcasing students' work | 4 | 13 |

be identifiable from the personal opinions expressed, contexts, and the small number of participants, resulting in participants losing their anonymity.

Transcriptions of the teacher interviews were used as the primary data source for the analysis, with the other data used to clarify or confirm findings. The interview recordings were professionally transcribed and imported to NVivo 12 for thematic analysis using an inductive-deductive approach. The first author open-coded five of the interviews. Displaying techniques were used to discover connections between these codes [34] and cluster similar codes together into themes, and journaling was used to reflexively consider and record further changes to the codebook [6]. The second author coded 20% of the transcripts and met with the first author to discuss differences and potential changes to the coding. A Cohen's Kappa reliability score of 0.71 was calculated, which is considered good agreement. The final four interviews were then coded using the agreed version of the codebook and the resulting themes were mapped to the AO Prompts as part of the analysis.

To investigate RQ2, all interview transcripts were categorised deductively using the FoI framework (see Figure 1) by the first and second authors, who discussed and agreed on all allocations.

# 4 RESULTS

## 4.1 Resource adaptations

Seven themes were generated from the analysis of the teacher interview transcripts (see Table 3) and these themes reveal the main types of adaptations made. In the following narrative about each theme, we have mapped which Areas of Opportunity (AO) Prompts (see Table 1) mostly raised the discussion about that type of adaptation.

*4.1.1 Open-ended application of skills.* In response to AO Prompt 6, to provide opportunities for learners to participate in open-ended activities, and AO Prompt 4, to review contexts and make teaching relevant and meaningful, teachers co-designed and added activities that allowed each student to practice skills by creating personalised images. Teachers placed these activities in later lessons in each unit of work, either lesson 5 or 6. Every teacher talked about aspects of these open-ended activities during their interview.

Nine teachers described how they supported students in these adapted activities. Approaches included students planning individually (Teacher 203) or as a group (Teacher 403) before starting to work digitally, or providing targeted support to a smaller group of students who needed additional help (Teacher 302). Teacher 204 asked questions to prompt his students, who were using their image editing skills to merge different parts of animals together to make a whole. Teacher 302 described how she used careful questioning to elicit ideas from students, who were almost all white British and had been struggling to think of background images to represent important features of their own backgrounds.

> *"I said, well, is there anything you do at home that you look forward to every week or every month or something? And one of them said, we always get a McDonald's on a Friday. I said, ... great, that's something you do with your family that is part of you, and they were like, wow. And then loads of them had loads of things to say. Oh ... we do this, we have a movie night once a month. And I thought, these are all things you do with your family that create and inspire what you do."* (Teacher 302)

Despite careful support, teachers also identified several barriers to students applying skills in open-ended activities. Teachers in Image Editing Group B noted students' struggles in selecting animals to symbolise their identity. For example, Teacher 201 explained that students *"understood what identity was as a concept, but they were finding it hard to apply to themselves and reflect on what they want to have to show for themselves"*. In Vector Graphics Group C, Teacher 301 observed some students struggling to choose a hobby and draw a vector graphic to represent it, and suggested that this may have been because of the low-income financial status of many families in the local area, which prevented students from participating in paid-for extra-curricular activities.

Eight teachers created their own example images or graphics, as well as modelling the technical skills in the original unit. This adaptation aided students in understanding the task (Teachers 203, 204, 302, 403), set expectations for the final piece (Teachers 204 and 301), and demonstrated openness in sharing identities within the classroom (Teachers 203, 204, 301). However, Teacher 403 found that while demonstrating how to create a vector graphic of a digital games device, most students replicated the example, and Teacher 303 thought their choice of a beach picture for a background might have influenced some students to do the same.

> *" ... when I did my model, I showed them a picture of the beach, because I said one of my favourite things to do is the beach ... maybe next time, if I do this lesson again, ... I wouldn't model so explicitly, because I think my choosing beach to represent me, might have steered the girls, because quite a few girls chose park, nature, beach. Two of them chose beach."* (Teacher 303)

*4.1.2 Discussing social, ethical or cultural issues.* All teachers described adaptations to include more whole-class discussions of social, ethical or cultural issues connected to computing, which had been made in response to AO Prompt 3, to add culturally relevant content, and AO Prompt 7, to develop student-oriented learning through structured group discussion. The discussions covered topics such as consent for editing photos in Group B, and representation in digital emoji sets for Groups C and D. In response to an interview question about AO Prompt 10, related policies and processes in the

school, teacher 403 described how her school's curriculum policy supported effective discussions with her class.

> *"Especially when it comes to topics like this ... we have P4C [philosophical enquiry activities] as well. Any sort of social discussions, anything like that where it's personal discussions, the children have a really good understanding of how to be respectful and understanding others."* (Teacher 403)

The adapted resources contained stimuli such as pictures and videos to initiate these discussions, and teachers reported adapting the lessons further to respond to additional contexts provided by students of their own experiences. For example, teacher 201's students had seen edited images in adverts.

> *"So they started off just saying which ones [adverts] they thought were real or fake. And then one child said, it's like when I've watched a video about how the food adverts, they might spray them with hairspray or put glue on them instead of cheese, so it looks better, and then when you get it, it doesn't actually look like that. And that sparked loads of other children going, I've seen them do that for this person when they're modelling, or I've watched a video like that, and they all fed in on it."* (Teacher 201)

Teachers also described how they faced the decision of extending discussions based on additional experiences that students shared, or proceeding to teaching digital skills. Teacher 101 chose to focus on technical skills to align with the timings in the lesson plans, while Teacher 402 had timetabling constraints of 45-minute lessons, so prioritised the technical skills in the time available. Teacher 303 emphasised the thoughtful consideration needed to balance teaching skills and competencies versus the extra time needed to be culturally responsive in class discussions.

> *"And I think that's a struggle for all teachers always... you want to teach the skills, you want to teach the competencies, but you also want to honour the individual. And sometimes, it's like a real balance".* (Teacher 303)

*4.1.3 Amending or adding examples for relevance.* Nine teachers described adding extra examples that they thought would be relevant to the students in response to AO Prompt 4, to make teaching relevant, and AO Prompt 6, to provide opportunities for inquiry-led activities. For example, three teachers in Vector Graphics Groups C and D played a game where they showed part of a logo, and students guessed the brand. Teachers in Image Editing Group B modified a photo of their school and asked students to identify the alterations, which prompted discussions between students and their families in one instance.

> *"They loved the class one that we shared, where it's the front of our school being really relevant ... that's what they were talking to parents about as well. When we were at the pickup, lots of them were saying, look, she managed to get rid of this, all of the old, out-of-date posters."* (Teacher 202)

*4.1.4 Introducing technical vocabulary.* Eight teachers talked about adaptations that they had made to the resources to help their students learn technical vocabulary in each unit, and level the playing field of knowledge-building for all. These changes were made in response to AO Prompt 5, which calls for content to be accessible for all learners. All four groups co-designed activities to scaffold the introduction and support student understanding of key terms like "vignette" or "HEX code". Teacher 204 described how he created an additional reference sheet with visual representations of key vocabulary and corresponding pictures to reduce language barriers for students when they used their new skills.

> *"With their final photo, they were able to go back to this and think, oh, actually what skills am I going to have to use, and what are the names of those skills?"* (Teacher 204)

*4.1.5 Encouraging independent experimentation.* In response to AO Prompt 8, to develop student-oriented learning through student choice, eight teachers shifted from demonstrating new skills to encouraging students to experiment independently with the software. Teachers called this "tinkering" or "tinker time", and the approach varied regarding the level of student autonomy. Teacher 203 told students, *"you can choose your picture, you can crop it, you can do whatever you want to that picture"*. Teacher 204 organised practice-specific tasks before allowing independent experimentation, and Teacher 302 displayed guidelines on the board to aid student software exploration, which they felt was effective.

> *"... they picked up more than if I had sat there and taught them how to do everything. I felt like they retained a lot more because they were experiencing it themselves."* (Teacher 302)

*4.1.6 Introducing more group activities.* Five teachers increased student group work in their classrooms in response to AO Prompt 7, to develop student-oriented learning through collaboration. For instance, Teacher 202 amended an activity so students worked in groups to colour in aspects of an image and discuss their choice.

> *".. they worked really well as a group, they were developing the idea of having to communicate together. One person was picking a person number in the image in the crowd to colour in, and then they would take it turns to guess and say why they thought it might be that."* (Teacher 202)

*4.1.7 Showcasing students' work.* Four teachers described making adaptations to showcase students' work to others both within the classroom and to the wider school community. This modification was influenced by AO Prompt 9, which calls for teachers to review the learning environment to increase a sense of belonging. Teacher 202 displayed printouts of the final images in the classroom, while Teacher 301 planned an exhibition of completed images for parents. Teacher 403 praised great examples of student work during lessons, which led to students spontaneously admiring each other's work. Teacher 303 arranged short showcases at the end of each session and invited the headteacher to a larger celebration for the unit's conclusion, and described how this activity built representation.

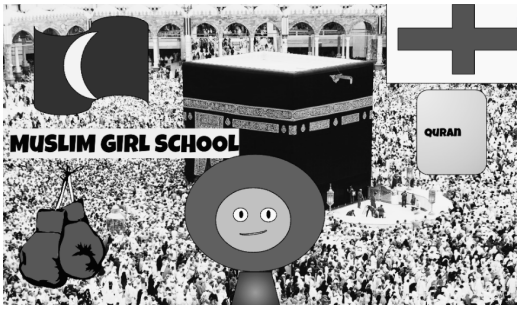


**Figure 2: A completed student artefact (Group C)**

*"The modification that I made to lesson six was... a celebration. And a showcase... we printed off all of their background slides with their emojis ... And then we stuck it up on the wall, close together, so they moved it around saying this one goes better here. So, we built it on together as a building activity, and that's when they got to talk about, well this is what this represents."* (Teacher 303)

## 4.2 Categorisation using funds of identity

During the analysis, we noticed that the added open-ended activities co-designed by all four groups particularly encouraged students to express their identities. Teachers in Group A co-designed an activity to create a digital collage about themselves and their interests. In Group B, teachers devised an activity where students digitally edited several images of animals to create an animal that represented them. The activities in Group C comprised creating a logo, a hobby, an emoji and a background as vector graphics. In Group D, students created an emoji and an avatar of themselves, and then added their avatar to an online game. We, therefore, used the funds of identity (FoI) framework (see Section 2.3) as a lens to analyse the teachers' descriptions of student artefacts.

An example of a completed student vector graphic is shown in Figure 2. This graphic was created by one of Teacher 301's students. In this artefact, the funds of identity revealed are as follows:

- The two flags are *cultural* artefacts.
- The background showing Mecca is both a *geographical* place and *ideological* part of the student's beliefs.
- The boxing gloves are a *practical* activity.
- The Quran is an *ideological* part of the student's beliefs.
- The hijab worn by the student is both a *cultural* artefact and an *ideological* part of the student's beliefs.
- The text "Muslim girl school" describes the intersection of the student's *ideological* beliefs, gender (*cultural*) and an *institutional* setting.

To better understand the use of identity artefacts in the co-designed activities, we categorised the teachers' descriptions of both self-created and student-created identity artefacts against the types of funds of identity [12, 31]. The results are shown in Table 4.

Analysis showed that students most frequently drew on practical (e.g. football, drawing), social (e.g. dad, sister, friend) and existential (e.g. quiet, angry, cool) FoI in their identity artefacts. Teachers also frequently drew on practical and social FoI, but were more likely to draw on institutional FoI such as weddings and graduations.

**Table 4: Summary of funds of identity identified in interview data by students (ST) and teachers (T) (* [31])**

| Categories of funds of identity * | Cases # (n=12) | Segments # | Data examples |
|---|---|---|---|
| Practical (ST) | 10 | 36 | football, drawing |
| Practical (T) | 7 | 20 | gardening, films |
| Social (ST) | 7 | 17 | dad, sister, friend |
| Social (T) | 7 | 12 | sibling, daughter, wife |
| Existential (ST) | 7 | 17 | quiet, angry, cool |
| Existential (T) | 5 | 8 | affectionate, chatty |
| Institutional (ST) | 6 | 11 | school, family, |
| Institutional (T) | 9 | 16 | school, graduation |
| Ideological (ST) | 4 | 7 | Islam, Jehovah's Witness |
| Ideological (T) | 3 | 8 | Catholicism, Islam |
| Geographical (ST) | 3 | 11 | beach, Somalia, Kuwait, |
| Geographical (T) | 2 | 4 | local area, beach, Ireland |
| Cultural (ST) | 3 | 7 | flag, braids, hijab |
| Cultural (T) | 5 | 9 | flag, language |

Interview responses, particularly from questions about AO Prompt 1, finding out about students, showed that teachers intended to incorporate more opportunities to draw on students' identities into future computing lessons when introducing new units of work.

> *"I think a lot of the discussion that we had around it at the workshop was about children's different backgrounds and, actually, do we know, when we start units of work, where they're all starting from? A lot of the time, no, we don't know their experiences at home or what they've done previously, outside of what school units of work have been ... And that's something that maybe we actually need to consider more"* (Teacher 201)

Teachers also shared aspects of their own identities with students as they created example material to model for students. In interviews, teachers reflected on this sharing, but this was in general, rather specifically from responses to questions about AO Prompt 2 find out about ourselves as practitioners.

# 5 DISCUSSION

## 5.1 RQ1: Culturally responsive adaptations

Addressing the first research question, **RQ1: In what ways do K-5 teachers collaboratively adapt resources to deliver culturally responsive computing teaching?**, we aimed to explore how teachers adapted computing resources to be culturally responsive to their students. Using the prompts from the Areas of Opportunity (see Table 3), we found that teachers made more changes to the context of lessons than to the content and that teachers modified their pedagogical approaches to increase accessibility for their learners

and added more open-ended activities, collaboration, group discussion, and student agency. We also found emerging evidence of how teachers use student work in their classrooms to promote a sense of belonging in computing, through the use of showcasing. The implications of these adaptations and how they relate to previous work are discussed in the rest of this section.

All four groups of teachers adapted the existing resources by adding open-ended activities for students to apply their skills. Previous studies have found that open-ended activities can be personally meaningful for students by using computing as a tool to solve problems that matter to them (e.g. [35, 38]). Specifically, our teachers allowed students to personalise the activities with their own lived experiences, such as their interests and families. These ideas have been used in more generalist research into culturally responsive teaching with K-5 students (e.g. [14]) and may offer new ways of applying culturally responsive principles to culturally responsive computing teaching (CRCT).

Unlike earlier research in which discussing sociocultural issues was awkward for students [2], students in this study freely offered their own ideas and opinions, prompting teachers to consider further adapting and integrating these contributions into their lessons. This may be because this study was carried out in a formal setting with K-5 students who knew their teachers well, whereas the previous study was with students in an extra-curricular programme who needed time to build trust with their instructors.

Teachers added relevant examples to draw on students' lived experiences and connect computing topics to real-world examples. This finding is consistent with previous research in England into computing teachers' existing culturally responsive practices [19]. The use of sociocultural symbolic representation, such as popular logos and emojis in these examples, is also consistent with previous research into culturally responsive computing that used simulated characters in virtual worlds[40]. The adaptations that used a picture of the students' own school prompted them to discuss computing outside the classroom. Building connections between teachers, students, and their community is an important theme of culturally responsive teaching [28], and we suggest that using local buildings and landmarks in learning materials may be one way to do this.

Hwang et al. describe how computing vocabulary can be difficult to learn and suggest that teachers may hesitate to teach certain topics because of their beliefs that the content is too challenging for their students [19]. In this study, teachers adeptly co-designed activities to make materials accessible for all by helping students learn technical computing vocabulary, which aligns with previous findings that connected Universal Design for Learning principles with culturally responsive teaching and identified the importance of providing multiple means of representation of new terms [22].

The remaining adaptation themes describe further pedagogical changes that teachers made to deliver the resources. Allowing students to independently experiment with new software provided a sense of agency that positively affected teachers' perceptions of their students' learning outcomes, which aligns with one of the core components of culturally responsive-sustaining computer science education [20]. Introducing more group work provided opportunities for peer-to-peer feedback, and this may have also contributed toward the showcasing adaptations that are discussed further in the next section. This is an emerging example of peer pedagogy, which has been previously identified as a practical way that teachers can be equitable in computing learning environments [27].

The adaptations co-designed by teachers using the Areas of Opportunity prompts broadly aligned with features of other computing resources that were specifically designed to be culturally responsive [27, 28] and contain more challenging computing topics such as programming, but whether these findings apply to other topics has yet to be evidenced. The seven themes of adaptations aligned with all ten AO Prompts. Interviewed teachers reflected less on their school policies and processes (AO Prompt 10) than on the other prompts. The adaptation theme of showcasing students' work came from AO Prompt 9 to review the learning environment and promote a sense of belonging. However, showcasing artefacts also contributed towards a sense of community and future work could explore how the AO Prompts could be expanded to prompt teachers to consider building a sense of community between students, teachers, parents and the wider school community.

## 5.2 RQ2: Use of identity

The second research question, **RQ2: What does a funds of identity analysis reveal about computing resource adaptations?**, sought to reveal more about how teachers used identity in their adapted computing activities. Teachers' descriptions of identity artefacts showed that students drew on all five of the original FoI described by Esteban-Guitart and Moll [12] as well as the additional funds proposed by Poole [31]. We interpreted some items as belonging to more than one fund, for example, the hijab, which differed from the approach taken in previous categorisations [12, 31]. We felt it was important to align with the Vygotskian concept of *perezhivanie* and recognise that students' identities may be mediated by more than one sociocultural influence at a time. So for example, an item of clothing such as the hijab may be worn both because it is considered a symbol of both culture and ideology.

We found the image representation topic in computing curricula can be used to create identity artefacts with students. Previous research has divided cultural contexts into heritage culture and vernacular culture (e.g. [28]), and we found that the FoI categories provided greater insight into the important aspects of both teachers' and students' lives. In our study, students were most likely to reveal practical FoI, such as leisure activities and hobbies. It is important to note that funds of identity are not static; they evolve over time and adapt to changing circumstances [12]. By using FoI, we start to conceptualise the diverse cultural resources that learners draw upon to construct their identities within the K-5 computing classroom. The FoI revealed in these artefacts may be able to be mobilised by teachers to inform ways to further adapt and contextualise their teaching [12, 46]. However, we posit that different types of FoI may be drawn upon in other computing topics. For example, a lesson on networking might relate more to students' personal networks and draw on students' social and institutional FoI. These examples are context-specific to the English computing curriculum, and to these students and their teachers. Further work could also explore the FoI revealed by students in other countries, age groups and for other topics in the computing curriculum.

However, the findings also show that there are important considerations for teachers when using identity artefacts in the classroom.

Although teachers' descriptions of the FoI revealed in artefacts showed that students were likely to draw on practical and existential FoI, teachers must be aware that creating an artefact to describe a hobby may be more challenging for students from lower socioeconomic backgrounds, and that K-5 students may find it more difficult to create an artefact that is more symbolic and abstract. Furthermore, the original resources recommended that teachers model concepts and skills to learners, but teachers should carefully consider which funds of their own identity to reveal when modelling identity artefacts, as their choices may influence those of their students. It should also be noted that teachers had to carefully support some students to illuminate their funds, including students from white British backgrounds, which adds to Esteban-Guitart's assertion that pedagogical techniques to surface invisible FoI are important, and this could be explored in future research [11].

The emerging use of artefact showcasing was an interesting finding, because this activity began to explore the collective identity of some classes, and to create identity-affirming spaces that have been used in previous STEM and computing research to promote inclusivity and a sense of belonging [20, 47]. It is this type of work that is likely to connect students' identities to their perceived idea of a typical computing student and provide underserved groups with a positive template for self-identification [17, 35].

To the best of our knowledge, this is the first study in England to use a FoI lens to analyse teachers' descriptions of K-5 students' culturally responsive computing artefacts. The FoI reported in this study are described as they were perceived by participating teachers, and future work could include data collection of students' work to incorporate artefact analysis and students' own explanations. An important part of CRCT is building rapport with students by finding out more about their beliefs, prior knowledge, and lived experiences, and considering how this may influence their views about computing [19, 46] and the findings from this study show how this can be practically achieved in computing through making resource adaptations.

### 5.3 Limitations

The resource adaptations were made specifically for image representation lessons that covered digital literacy skills in the K-5 computing curriculum. Whether these findings would be seen in other digital literacy topics, such as manipulating data, or more widely in algorithmic thinking and programming topics remains to be explored. Furthermore, despite checking the resource changes with teachers and teachers having the opportunity to make changes independently during the delivery phase, the resources were adapted by researchers acting as resource developers and this could have introduced researcher bias. Additionally, the small sample size of participants limits the generalizability of the findings.

## 6 CONCLUSION AND NEXT STEPS

In this small-scale, qualitative study, we have examined how K-5 teachers in England co-design culturally responsive adaptions to computing resources using a set of ten prompts called Areas of Opportunity. We found that teachers made more adjustments to the context of lessons than altering the content. Participating teachers adapted their teaching methods to increase accessibility for students and add more open-ended activities, collaboration, group discussions, and opportunities for student agency. Additionally, we observed how some teachers used showcasing of student work to encourage a sense of belonging in computing classrooms and the wider school community. The adaptations drew on prompts from all ten Areas of Opportunity. Additional work could explore how to improve the Areas of Opportunity to prompt teachers to build a sense of community between home, school and the wider community. The Areas of Opportunity were effective for adapting resources and the funds of identity useful for exploring identity in artefacts, therefore, we suggest resource developers and other researchers may find the approach similarly useful to explore in curriculum material design and research.

Teachers co-designed activity adaptations to draw on the lived experiences and identities of students. The image representation topic of computing was well suited to allow students in this study to mobilise their funds of identity and see themselves represented in the computing classroom. As next steps, future work could explore how teachers use the funds illuminated in these identity artefacts to contextualize other topics in computing, analyse student identity artefacts and explore students' own descriptions of their funds of identity, and connections to computational thinking could also be made. More widely, the relationship between FoI and gender or FoI and capital could be explored in further research. This study contributes to our understanding of the culturally responsive adaptations that K-5 teachers in England make to image representation lessons. The Areas of Opportunity prompts are scaffolds that may be used by other teachers to identify adaptations to these lessons. Despite the small sample size, the findings about how teachers incorporate identity in their adaptations contribute to our understanding of applying sociocultural theories to student identity in computing. We suggest this advancement may promote a sense of increased belonging and equity, and potentially enhance the diversity of students on elective computing courses and careers.

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## REFERENCES

[1] Louise Archer, Jen DeWitt, Spela Godec, Morag Henderson, Henriette Holmegaard, Qian Liu, Emily MacLeod, Heather Mendick, Julie Moote, and Emma Watson. 2023. *ASPIRES3 Summary Report: Computing.* Technical Report. London, UCL. https://discovery.ucl.ac.uk/id/eprint/10182299

[2] Catherine Ashcraft, Elizabeth K Eger, and Kimberly A. Scott. 2017. Becoming technosocial change agents: Intersectionality and culturally responsive pedagogies as vital resources for increasing girls' participation in computing. *Anthropology & Education Quarterly* 48, 3 (2017), 233–251.

[3] BCS. 2021. *BCS diversity report 2021: Women in IT.* Technical Report. BCS, The Chartered Institute for IT, UK. https://www.bcs.org/policy-and-influence/diversity-and-inclusion/bcs-diversity-report-2021-women-in-it/

[4] Alessandro Bello, Tonya Blowers, Susan Schneegans, and Tiffany Straza. 2021. To be smart, the digital revolution will need to be inclusive.. In *UNESCO Science Report: the Race against Time for Smarter Development.* UNESCO, Paris.

[5] British Educational Research Association. 2018. *Ethical guidelines for educational research* (4 ed.). British Educational Research Association, London. https://www.bera.ac.uk/resources/all-publications/resources-for-researchers

[6] David Byrne. 2022. A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Quality & quantity* 56, 3 (2022), 1391–1412.

[7] Maya Denton and Maura Borrego. 2021. Funds of knowledge in STEM education: A scoping review. *Studies in engineering education* 1, 2 (2021).

[8] Department for Education, England. 2014. Promoting fundamental British values as part of SMSC in schools. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/380595/SMSC_Guidance_Maintained_Schools.pdf Last accessed 22nd Jan 2023.

[9] Department for Education, England. 2023. *School workforce in England.* Technical Report. Department for Education. https://explore-education-statistics.service.gov.uk/find-statistics/school-workforce-in-england Last accessed 29th Dec 2023.

[10] Moises Esteban-Guitart. 2021. Advancing the funds of identity theory: A critical and unfinished dialogue. *Mind, Culture, and Activity* 28, 2 (2021), 169–179.

[11] Moisès Esteban-Guitart. 2023. Invisible funds of identity in urban contexts. *Urban Education* 58, 7 (2023), 1449–1469.

[12] Moisès Esteban-Guitart and Luis C Moll. 2014. Funds of identity: A new concept based on the funds of knowledge approach. *Culture & Psychology* 20, 1 (2014), 31–48.

[13] Katrina Falkner, Sue Sentance, Rebecca Vivian, Sarah Barksdale, Leonard Busuttil, Elizabeth Cole, Christine Liebe, Francesco Maiorana, Monica M. McGill, and Keith Quille. 2019. An International Study Piloting the MEasuring TeacheR Enacted Computing Curriculum (METRECC) Instrument. In *Proceedings of the Working Group Reports on Innovation and Technology in Computer Science Education.* ACM, Aberdeen, Scotland, United Kingdom, 111–142. https://doi.org/10.1145/3344429.3372505

[14] Amy Seely Flint and Wanda Jaggers. 2021. You matter here: The impact of asset-based pedagogies on learning. *Theory Into Practice* 60, 3 (2021), 254–264.

[15] Diana Franklin, David Weintrop, Jennifer Palmer, Merijke Coenraad, Melissa Cobian, Kristan Beck, Andrew Rasmussen, Sue Krause, Max White, Marco Anaya, et al. 2020. Scratch Encore: The design and pilot of a culturally-relevant intermediate Scratch curriculum. In *Proceedings of the 51st ACM technical symposium on computer science education.* 794–800.

[16] Geneva Gay. 2000. *Culturally responsive teaching: theory, research, and practice.* Teachers College Press, New York.

[17] Gregor Groesse-Boelting, Dietrich Gerstenberger, Lara Gildehaus, Andreas Muehling, and Carsten Schulte. 2021. Identity in K-12 Computer Education Research: A Systematic Literature Review. In *Proceedings of the 17th ACM Conference on International Computing Education Research* (Virtual Event, USA) *(ICER 2021).* ACM, New York, NY, USA, 169–183. https://doi.org/10.1145/3446871.3469757

[18] Apriel K. Hodari, Maria Ong, Lily T. Ko, and Rachel R. Kachchaf. 2014. New Enactments of Mentoring and Activism: U.S. Women of Color in Computing Education and Careers. In *Proceedings of the Tenth Annual Conference on International Computing Education Research* (Glasgow, Scotland, United Kingdom) *(ICER '14).* ACM, New York, NY, USA, 83–90. https://doi.org/10.1145/2632320.2632357

[19] Yujeong Hwang, Anjali Das, Jane Waite, and Sue Sentance. 2023. Using a Sociological Lens to Investigate Computing Teachers' Culturally Responsive Classroom Practices. In *Proceedings of the 2023 ACM Conference on International Computing Education Research - Volume 1* (Chicago, IL, USA) *(ICER '23).* ACM, New York, NY, USA, 206–221. https://doi.org/10.1145/3568813.3600112

[20] Kapor Centre. 2021. *Culturally responsive-sustaining CS education: a framework.* Technical Report. Kapor Centre, USA. 14 pages. https://www.kaporcenter.org/wp-content/uploads/2021/06/1_CRCSFramework-Report_v7_for-web-redesign-.pdf Last accessed 22nd Jan 2023.

[21] Peter E. J. Kemp, Billy Wong, and Miles G. Berry. 2019. Female Performance and Participation in Computer Science: A National Picture. *ACM Trans. Comput. Educ.* 20, 1, Article 4 (nov 2019), 28 pages. https://doi.org/10.1145/3366016

[22] Laura Kieran and Christine Anderson. 2019. Connecting Universal Design for Learning With Culturally Responsive Teaching. *Education and Urban Society* 51, 9 (2019), 1202–1216. https://doi.org/10.1177/0013124518785012 arXiv:https://doi.org/10.1177/0013124518785012

[23] Gloria Ladson-Billings. 1995. Toward a Theory of Culturally Relevant Pedagogy. *American Educational Research Journal* 32, 3 (Sept. 1995), 465–491. https://doi.org/10.3102/00028312032003465

[24] Hayley C. Leonard, Katharine Childs, Jane Waite, Robert Whyte, and Sue Sentance. 2023. Engaging Primary (K-5) Computing Teachers in Culturally Relevant Pedagogy through Professional Development. In *Proceedings of the 2023 Conference on United Kingdom & Ireland Computing Education Research* (Swansea, Wales Uk) *(UKICER '23).* ACM, New York, NY, USA, Article 6, 7 pages. https://doi.org/10.1145/3610969.3611118

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

[26] Mariona Llopart, Josep Maria Serra, and Moises Esteban-Guitart. 2018. Teachers' perceptions of the benefits, limitations, and areas for improvement of the funds of knowledge approach. A qualitative study. *Teachers and Teaching* 24, 5 (2018), 571–583.

[27] Tia C. Madkins, Nicol R. Howard, and Natalie Freed. 2020. Engaging Equity Pedagogies in Computer Science Learning Environments. *Journal of Computer Science Integration* 3, 2 (Nov. 2020), 1–27. https://doi.org/10.26716/jcsi.2020.03.2.1

[28] Jessica Morales-Chicas, Mauricio Castillo, Ireri Bernal, Paloma Ramos, and Bianca Guzman. 2019. Computing with Relevance and Purpose: A Review of Culturally Relevant Education in Computing. *International Journal of Multicultural Education* 21, 1 (March 2019), 125–155. https://doi.org/10.18251/ijme.v21i1.1745

[29] Lijun Ni, Gillian Bausch, Bernardo Feliciano, Hsien-Yuan Hsu, and Fred Martin. 2022. Teachers as curriculum co-designers: Supporting professional learning and curriculum implementation in a CSforAll RPP project. In *2022 Conference on Research in Equitable and Sustained Participation in Engineering, Computing, and Technology (RESPECT).* National Science Foundation, Alexandria, VA, USA, 1–8.

[30] Nisha Parhar and Ozlem Sensoy. 2011. Culturally relevant pedagogy redux: Canadian teachers' conceptions of their work and its challenges. *Canadian Journal of Education* 34, 2 (2011), 189–218.

[31] Adam Poole. 2017. "I want to be a furious leopard with magical wings and super power": Developing an ethico-interpretive framework for detecting Chinese students' funds of identity. *Cogent Education* 4, 1 (2017), 1316915.

[32] Raspberry Pi Foundation. 2023. The computing curriculum. https://www.raspberrypi.org/curriculum

[33] Raspberry Pi Foundation. 2023. Culturally adapted resources for primary schools - Project Website. https://www.raspberrypi.org/research/projects/culturally-adapted-resources-for-primary-schools

[34] Kate Roberts, Anthony Dowell, and Jing-Bao Nie. 2019. Attempting rigour and replicability in thematic analysis of qualitative research data; a case study of codebook development. *BMC medical research methodology* 19 (2019), 1–8.

[35] Jean J. Ryoo and Kendrake Tsui. 2023. Defining a "Computer Science Person" and the Pedagogical Practices Supporting Positive Identification for Minoritized Youth. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1* (Toronto ON, Canada) *(SIGCSE 2023).* ACM, New York, NY, USA, 673–679. https://doi.org/10.1145/3545945.3569794

[36] Jean Salac, Alannah Oleson, Lena Armstrong, Audrey Le Meur, and Amy J. Ko. 2023. Funds of Knowledge used by Adolescents of Color in Scaffolded Sensemaking around Algorithmic Fairness. In *Proceedings of the 2023 ACM Conference on International Computing Education Research - Volume 1 (ICER '23).* Association for Computing Machinery, New York, NY, USA, 191–205. https://doi.org/10.1145/3568813.3600110

[37] Innovation Science and Technology Committee. 2023. *Diversity and inclusion in STEM: Government Response to the Committee's Fifth Report.* Technical Report. House of Commons, UK. https://committees.parliament.uk/publications/40456/documents/197355/default/

[38] Kimberly A. Scott, Kevin Clark, Elisabeth Hayes, Cynthia Mruczek, and Kimberly Sheridan. 2010. Culturally relevant computing programs: Two examples to inform teacher professional development. In *Society for information technology & teacher education international conference.* Association for the Advancement of Computing in Education (AACE), Waynesville, NC USA, 1269–1277.

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

[40] Kimberly A. Scott and Mary Aleta White. 2013. COMPUGIRLS' Standpoint: Culturally Responsive Computing and Its Effect on Girls of Color. *Urban Education* 48, 5 (Sept. 2013), 657–681. https://doi.org/10.1177/0042085913491219

[41] Sue Sentance, Diana Kirby, Keith Quille, Elizabeth Cole, Tom Crick, and Nicola Looker. 2022. Computing in School in the UK & Ireland: A Comparative Study. In *The United Kingdom and Ireland Computing Education Research (UKICER) Conference.* ACM, Dublin Ireland, 1–7. https://doi.org/10.1145/3555009.3555015

[42] Royal Society. 2017. After the Reboot: Computing Education in UK Schools.

[43] Minh Tran, Heather Killen, Jen Palmer, David Weintrop, and Diana Franklin. 2024. Harmonizing Scratch Encore: Scaffolding K-8 Teachers in Customizing Culturally Responsive Computing Materials. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1* (, Portland, OR, USA,) *(SIGCSE 2024).* Association for Computing Machinery, New York, NY, USA, 1335–1341. https://doi.org/10.1145/3626252.3630756

[44] Emiliana Vegas, Michael Hansen, and Brian Fowler. 2021. *Building skills for life. How to expand and improve computer science education around the world.* Technical Report. The Brookings Institution, Washington DC, USA. https://www.brookings.edu/wp-content/uploads/2021/10/Building_skills_for_life.pdf

[45] Lev Semenovich Vygotsky. 2016. *The collected works of LS Vygotsky: Problems of general psychology, including the volume thinking and speech.* Springer, New York, NY, USA.

[46] Jane Waite, Anjali Das, Hwang Yujeong, and Sue Sentance. 2023. Culturally relevant Areas of Opportunity for K-12 computing lessons. In *2023 IEEE Frontiers in Education Conference (FIE).* IEEE, College Station, Texas, USA, 6 pages. In press.

[47] Annie M. Wofford and Justin A. Gutzwa. 2022. Funds of Science Identity: Toward AN Asset-Based Framework for Undergraduate STEM Research and Praxis. *Journal of Women and Minorities in Science and Engineering* 28, 3 (2022), 59–81.

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