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Culturally Responsive-Sustaining Computational Thinking: Enactment in Elementary Classrooms

RESEARCH

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ABSTRACT

Technology has increasingly permeated many aspects of everyday life and this evolution raises the need for individuals to understand how the digital world works and what opportunities and risks it brings (Nouri, Zhang, Mannila & Norén, 2019). For this to be an experience for everyone, we need to rethink how we integrate computational thinking (CT) and provide teachers with tools to center their students' identities, experiences, and cultures in the classroom. In this paper, we present two case studies of primary (elementary) teachers from a full primary (student ages 5–13) semi-rural school in the North Island of New Zealand that showcase examples of their current CT integrated culturally responsive lessons and activities. Our findings show how elementary teachers implement culturally responsive approaches in CT lessons. Although a positive example of how CT can be integrated in a culturally responsive manner, we discuss our findings and their implications.

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INTRODUCTION

Technology holds a key role in our modern and connected world. The technological evolution has brought about the need for everyday individuals to understand how digital technology works and the opportunities and risks it may bring (Hepp, Hinostroza, Laval, & Rehbein, 2004; Nouri, Zhang, Mannila, & Norén, 2019). Because technology plays such a significant role in people's lives, we need to introduce computing concepts to students earlier in their schooling years (Ketelhut, Mills, Hestness, Cabrera, Plane, & McGinnis, 2020; Tai, Liu, Maltese, & Fan, 2006; Yadav, Hong, & Stephenson, 2016). One approach in how to introduce computing concepts to younger students is to integrate computational thinking (CT) across the curriculum areas they are already learning in class (Yadav et al., 2016; Rich, Yadav & Schwarz, 2019). Opportunities to learn computer science or CT, regardless of its value as an introduction to technology in a digital world, may represent a more broad opportunity for all people, however, seemingly cultural preferences and interests in computer science (CS) are impacted greatly by historical legacies, denied opportunities and structural inequity – compounded by a belief system that justify these inequities (Margolis, 2010). As a result, we need to rethink how we integrate computational thinking in ways that challenge the hegemonic nature of computer science and provide teachers with tools to center their students' identities, experiences, cultures, and community as assets in the classroom. In this paper, we discuss culturally responsive approaches for computational thinking (CT) integration into elementary classrooms. Specifically, we discuss a translanguaging example of CT integration using Te Reo Māori (the Māori language) to engage elementary students in Scratch and another example of integrating unplugged CT with pūrākau (myth, ancient legend, story) in New Zealand. We further discuss how elementary teachers' think to bring these culturally responsive approaches into their CT integrated lessons.

LITERATURE REVIEW

There has been rapid growth in the advancement of CT in educational contexts across the globe with arguments that CT concepts and skills are vital for success in an increasingly digital world (Weintrop, Wise Rutstein, Bienkowski & McGee, 2021). A review of the CT literature by Hsu, Chang, and Hung (2018) found that CT is an important subject in many countries, with national programs being created using new teaching content and textbooks. In these countries, students are being introduced to CT practices and tools from a young age with CT being viewed as a problem-solving skill that can be applied across disciplines and into daily life. Many researchers have argued that CT is a necessary 21st century skill for students to develop problem-solving skills by drawing on computer science principles (Selby, 2015; Shute, Sun & Asbell-Clarke, 2017). Wing (2008) also proposed that CT would become instrumental in almost all professions in the future, therefore becoming an integral part of what is needed in the education system. In 2017, the New Zealand Ministry of Education responded to this need by reviewing the technology learning area of the curriculum (Fox-Turnbull, 2018; Ministry of Education, 2018) and introduced CT as a new strand alongside a push for all schools to implement the new CT requirements by 2020.

CT has been defined as breaking down problems into smaller, more manageable sub-problems (decomposition), reviewing how the solution can be transferred to similar problems (abstraction), using a sequence of steps to solve those problems (algorithms), and lastly, determining if a computer can be used to solve those problems efficiently (Yadav et al., 2016). Researchers agree that CT involves higher-order thinking which may allow students to express problems and form solutions in such a way that a computer can solve them (Denning, 2017; Wing, 2017; Yadav, Hong & Stephenson, 2016); however, some have also argued that CT does not always involve technology (Armoni, 2016; Bell & Roberts, 2016). There have naturally been teething issues regarding implementation of CT throughout schools including how to train the teachers in CT content and pedagogy. Orvalho (2017) argued that governments need to train teachers in how to design CT tasks and content so the students can participate, improve their higher-level thinking strategies, and apply CT across curriculum areas. However until recently, relatively few primary/elementary teachers have been involved in formal training in either coding or CT (Rich & Hodges, 2017; Yadav et al., 2016).

While there has been a push to expand computing learning opportunities for all students, there has also been a push to do so in ways that center students and their lived experiences (Lachney & Yadav, 2020). Culturally responsive teaching (CRT), which focuses on the empowerment, transformation, validation and comprehension (Gay, 2018) of students provides a way to engage culturally and linguistically diverse youth in computing (Castagno and Brayboy, 2008; Scott, Sheridan, & Clark, 2015). CRT views a students' background, community and family as the foundation for which learning can occur (Haynes 2007; Scott et al., 2015). Gay (2002) argued that teachers' knowledge about cultural diversity needs to "go beyond mere awareness of, respect for, and general recognition of the fact that ethnic groups have different values or express similar values in various ways [and] requires acquiring detailed factual information about the cultural

particularities of specific ethnic groups" (p. 107). According to Ladson-Billings (1994), a culturally responsive approach to teaching would foster cultural competence and an ability to critique the social order, which are necessary skills for students to be both academically successful and socially conscious members of their world. Additionally, research has shown that culturally responsive teaching can improve academic achievement for students (Ladson-Billings 2006; Brown-Jeffy and Cooper 2011).

With regards to technology, Scott et al. (2015) argued that culturally responsive computing (CRC) is a necessity to develop individualized creation with technology, considering how the use and evolution of digital tools in social relationships and communities has significantly increased. The authors reviewed 50 technology programs available to minority groups, indicating that the vast majority of these courses focus on technical literacy (for example, programming) without mentioning the issues of diversity, community, or culture in the field. The authors argued that this is the antithesis to how we should be teaching CS given the value of culturally responsive teaching in increasing student outcomes, including sense of belonging and achievement (Howard & Terry, 2011). Furthermore, researchers have questioned whether technology creations reflect society (Conole, de Laat, Dillon, & Darby, 2008). To change this perspective, Scott et al., (2015) argue that CRC practices use asset-building approaches which encourage reflection and connection with their students and that teachers who are culturally responsive develop and demonstrate their own cultural competency towards their students' identities (Ware 2006; West-Olatunji, Behar-Horenstein, Rant, & Cohen-Phillips, 2008), use this understanding to build their lessons (Gay, 2010), and develop sustainable relationships with their students on the notion that they will be successful (Ware 2002; Brown-Jeffy and Cooper 2011).

There have been efforts over the last two decades to broaden access and participation in computer science for indigenous communities, however they have not had any discernible impact (Kafai, Searle, Martinez & Brayboy, 2014). There are a combination of factors enhancing this trend; lack of access to appropriate courses and resources (Margolis, 2010), inadequate teacher preparation (Goode, 2007), and insufficient cultural responsiveness when working with underrepresented people (Eisenhart & Edwards, 2004). Eglash, Gilbert and Foster (2013) have approached this divide through culturally responsive computing which has a focus on tools and environments for students to learn about computing and its cultural relevance.

While there are emerging instances of CRC, the majority of the examples are from the United States and we have few cases of how teachers use students' funds of knowledge and experiences from indigenous cultures in other countries. This paper focuses on how two primary/elementary teachers in New Zealand taught computational thinking by integrating CT with Te Reo Māori (the Māori language) and pūrākau (myth, ancient legend, story).

Culturally Sustaining Schooling (CSS) also known as cultural responsiveness is an approach to teaching where raising the achievement of the students who have historically been underserved (Castagno & Brayboy, 2008). According to the Alaska Native Knowledge Network (1998), cultural responsiveness means grounding language, culture, and history in students and communities, which is essential in identifying the practices involved in culturally sustaining educators, curriculum content, and schools. This approach requires different teaching and learning methods, a shift in teacher dispositions and wider community relationships with the school (Highfield & Webber, 2021). For New Zealand students, culturally responsive teaching and learning uses Māori students' cultural backgrounds as the context for their learning. Although a focus for almost 20 years in New Zealand education (Averill & McRae 2019), culturally responsive practices are still not reaching all Māori learners, regardless of their proven worth in improving students' learning (Hynds, Averill, Hindle, & Meyer, 2017).

In terms of computing education and CT, broadening participation is driven by the belief that all students can benefit from understanding CS practices and skills, regardless of which career they see themselves in, and the need to challenge the fact that most young people have been denied access to quality CS learning (Bobb, 2018; Margolis, 2010). In 2008, Exploring Computer Science (ECS) was created to address structural and curriculum inequalities that students from minoritized groups faced in high schools. Through an inquiry-based approach to teach CS, ECS believes that students learn best when problems relate to their own questions in their own worlds. In addition to broadening the curriculum, the pedagogy involved to support teaching content is imperative so all students have the opportunity to learn CS. Therefore, ECS provides teacher professional development using inquiry-based learning where teachers are provided opportunities to practice this learning, be observed doing so, and be part of a professional learning community (Goode et al., 2012).

Through the ECS program, research conducted by Ryoo (2019) via extensive interviews and observations, found that over 80% of students highly valued their teachers' method of relating CS to their everyday lives. In addition, over 50% of students described how CS connected to their lives increased their motivation to learn. Alongside this, almost 70% of the students in the study commented that they cared about equity issues in their lives and wanted their schooling to reflect their personal commitment to positively impact

their communities. For example, students emphasized how discussing pollution, racism, high unemployment rates, gang violence etc in their CS classes was of importance to them. Ryoo (2019) also found that the pedagogical efforts by the teachers to clearly link CS to everyday lives of the students and welcoming students' ideas, resulted in a positive impact towards their engagement in the course. In particular, teachers demonstrated how CS could be utilized for social issues impacting students' lives by welcoming student voices and perspectives on how to solve those problems. Goode and Ryoo (2019) have similarly argued that CS content knowledge is not enough on its own. Teachers must understand the cultural and historical contexts of their students and how those experiences impact their learning. The pedagogical knowledge required means focusing on students' prior lived experiences to create connections to new learning which is accessible and relevant to the students in their classes. In particular, showing how CS is intertwined in young people's lives, and how it is a subject they can feasibly learn and do. Lastly, teachers must create a safe space for students to share their unique understanding of CS and its real-world applications for them.

Similarly, Zha, Morrow, Curtis, & Mitchell, (2021) stated that educators need to consider students' own culture and daily lives when creating tasks and projects integrating CT. The authors also suggest trying to enable students to utilize projects in their own communities through the connection of class knowledge and real-world experience. In their research, they speculated whether CT integration in a Spanish class could broaden participation from minoritized groups. The researchers wanted to see how CT could be integrated into three high school Spanish classes with the goal to read, write, listen to and speak Spanish as well as discuss the various cultures of Spanish-speaking countries using Scratch software. Results suggested that although CT integration did not improve student learning Spanish language and culture, CT integration led to positive attitudes towards coding and student enjoyment of coding.

CS education researchers have also used CRC by drawing on students' indigenous and vernacular culture, such as music and crafts. For example, Krug and colleagues (2021) used hiphop to teach middle school students programming that significantly increased students' computing enjoyment, computing confidence, identity and belonging in computing, and intent to persist in computing. In another study, Kafai, Searle, Martinez & Brayboy, (2014) discuss teaching middle school students computing by connecting native arts and crafts with electronic computation through e-textiles.

Researchers have also supported teachers to bring CRC by connecting to students' home language through translanguaging. Translanguaging is applicable in K-12 CS classrooms, in particular how computer science is learned through language (Vogel et al., 2019). According to Garcia, and Wei (2014), translanguaging is the theory that people use a raft of meaning-making techniques, including linguistic resources (e.g. knowledge of vocabulary), semiotic resources (e.g. drawing) as well as social practices (e.g. conventions for greeting others). Translanguaging is applicable in K-12 CS classrooms, in particular how computer science is learned through language (Vogel et al., 2019).

There is currently a lack of research focused on translanguaging in CT education (Vogel et al., 2019), however there are examples of how translanguaging has been used in a variety of teaching areas as a way to support equity in education, particularly for emergent bilingual students (García, Johnson, Seltzer, & Valdés, 2017). Although previous work on translanguaging in CS has described how teachers can use English and Hindi (Pal & Iyer, 2015) to teach students how to program, those students did not yet provide researchers with an understanding of the relationship between students' translanguaging and computational thinking (Vogel et al., 2019). However, Vogel et al., (2019) found that when students use translanguaging practices alongside CS/CT they blur linguistic and disciplinary boundaries. They also found that the students used translanguaging practices to engage in specific CT practices (for example, abstraction).

METHOD

CONTEXT

In 2018, Computational Thinking (CT) and Designing and Developing Digital Outcomes (DDDO) for digital technologies was introduced into the New Zealand Curriculum and Te Marautanga o Aotearoa for both primary and secondary schools and kura kaupapa Māori (Māori-language immersion schools). The updated technology learning area emphasizes creation, problem-solving and innovation (Kellow, 2018). In this study, CT is the focus.

There are eight key principles in the New Zealand Curriculum (NZC) which underpin national and local school curriculum decisions. One of the principles is Te Tiriti ō Waitangi (the Treaty of Waitangi) and ensures that schools and teachers deliver a curriculum that acknowledges the Te Tiriti ō Waitangi principles, acknowledges the country's bicultural foundations, and enables students to acquire knowledge of Te Reo Māori (the Māori language) and tikanga Māori (Māori practices and values) (Te Kete Ipurangi, 2022b). A second principle is cultural diversity which means schools and teachers are required to deliver a curriculum that reflects a linguistically and culturally diverse nation, affirms students' different cultural identities, incorporates students'

cultural contexts into teaching and learning programmes, is responsive to diversity within ethnic groups, and helps students understand and respect diverse viewpoints, values, customs, and languages (Te Kete Ipurangi, 2022c). The two teachers we highlight in the case studies below come from a school in the central North Island of New Zealand where 19% of students identify as Māori.

PARTICIPANTS

Participants included two primary (elementary) school teachers from a full primary (student ages 5–13) semi-rural school in the North Island of New Zealand. Both teachers were part of a larger project that focused on how teachers integrate CT across curriculum areas. One teacher was male, and had been teaching between 10–20 years. The other teacher was female, and had also been teaching between 10–20 years (see Table 1).

PROCEDURE

The teachers had participated in 100 hours of government funded professional development (PD) in 2019. Led by a Ministry of Education facilitator, the PD introduced CT and how it could be implemented into their current teaching practices, across curriculum areas. The teachers had previously experienced using and designing both unplugged (without computers) and plugged (with computers) approaches. In 2021, the teachers participated in a semi-structured interview about their experience using CT, as part of a wider study. In our context, we used these interviews to form a deeper understanding of how the teachers used CT in a culturally responsive way. In addition, we asked the teachers to provide learning material where they had integrated CT with either Te Reo Māori, or pūrākau.

RESULTS

As discussed previously, culturally responsive approaches to computing have been highlighted as being important for broadening participation, yet there is little research at the elementary level on how we can support teachers in culturally responsive CT teaching practices. As a way to understand where support might be needed, we asked teachers to showcase their examples of culturally responsive CT integration in a New Zealand context for early middle students aged 11–12 and discuss how they centered Māori language and culture in their CT lessons. Below, we highlight two cases from Catherine and Peter on how they utilized culturally responsive computing to provide opportunities for their students to engage in computational practices using plugged and unplugged activities.

PSEUDONYM	GENDER	YEARS TEACHING	STUDENT AGE
Peter	Male	10–20	11–12
Catherine	Female	10–20	11–12

Table 1 Demographic information.

CULTURALLY RESPONSIVE COMPUTING THROUGH AN UNPLUGGED ACTIVITY: A CASE STUDY OF CATHERINE

Catherine used an unplugged activity that drew upon the local Māori culture to engage the students in CT practices (algorithmic thinking and debugging). In particular, Catherine used pūrākau (myth, ancient legend, story) to engage her students in CT. The students were asked to follow an algorithm through a grid overlaid on a map of the local area relating to the pūrākau. Students broke down a simple non-computerised task into a set of precise, unambiguous, step by step instructions (algorithmic thinking). They were able to receive and give these instructions and identify if they have gone wrong and correct them (debugging). By doing this, students showed their decomposition skills to take a task and break it down into the smallest steps. See Appendix 1 for the detailed activity.

When developing this activity, Catherine believed that it was important for her to understand her students well to engage them with CT, stating: "[If] a student's learning needs aren't being met, they aren't going to be able to access the curriculum". In addition, when discussing the unplugged example, Catherine described the school's strategic direction for integrating CT "around localized curriculum, teacher capability and around student agency as well. So those three concepts, for the next three years, lend themselves toward curriculum integration, effective pedagogy, and our DT [digital technology] / CT." This comment highlights how school policies and vision plays an important role in supporting teachers and gives them agency to implement curriculum in ways that contextualizes learning around their students and the community.

Using a localized curriculum essentially means weaving local stories and histories into the student's learning (Te Kete Ipurangi, 2022a). Catherine continued:

> There is always a constant lens on DT and this year in particular, a constant lens to make sure it's not just about 'oh we do DT one afternoon, one hour a week' – it's around 'how can we deliver our curriculum through DT and CT?'

During the interview, Catherine described how she was working on this activity as a wider project to integrate local

history into the school curriculum, with an emphasis on CT practices:

> A project that I've been working on is our pūrākau [myth, ancient legend, story] so that's like the local stories of the area which have been gifted to us from our ancestors. So as a leader, I've been sort of, I'm in my own little waka [canoe], my own project around trying to weave DT and in particular CT into those pūrākau so that the stories have a modern lens I suppose, for our learners.

Catherine found integrating CT to be more achievable within an unplugged context; "A lot of the PD delivered had nothing to do with a computer and I think that broke down a lot of the barriers right there for us. It created the ease to be able to apply across the curriculum".

Catherine also commented on the need to develop her understanding of how to connect CT with real-life situations. She stated:

> And I suppose for me, one of the hardest things I actually found was the application to real life. So it was quite easy to unpack CT, or look at decomposition and algorithms and stuff, but I was still trying to find my confidence and competence with the application [of CT] and how that impacts real life.

Catherine's unplugged example of a culturally responsive approach to computing highlights that we can provide teachers with different opportunities to center their students in computational practices, even without a computer.

CULTURALLY RESPONSIVE COMPUTING THROUGH A PLUGGED ACTIVITY: A CASE STUDY OF PETER

The plugged example is from Peter where he used Scratch software to develop the students' Te Reo Māori conversational skills. Peter had already been using his knowledge of his students to engage them in CT learning and commented, "just knowing the kids, knowing their background and what they're interested in and trying to hook them in a little bit and getting them to think".

With regards to CT instruction, Peter had co-developed an activity with a colleague using scratch software where the students developed their Te Reo Māori literacy skills (see Appendix 2) as well as utilize CT skills. In addition, Scratch can help students learn to think creatively, use systematic reasoning, and work collaboratively with one another (Shute et al., 2017). Peter had co-developed a lesson where the students used Scratch software to design and code a conversation between two characters in Te Reo Māori. There were three levels to this activity:

1. Basic – Characters said the words but there was no background;
2. Intermediate – Characters said the words via speech bubbles, and there was also a background, and sounds relating to the dialogue;
3. Advanced – Characters said the words via voice recordings, backgrounds related to the dialogue and may change, and the characters could move as they interacted.

The students were also provided a glossary of terms and sentence structures in English and Te Reo Māori.

In this case, using Scratch to write a program required an understanding of the problem (what is the goal?) with students breaking the problem into manageable chunks (decomposing the problem into individual steps/blocks to achieve the goal). Finally, students tested the program (finding and fixing problem areas), and this is where debugging was used.

When explaining the activity, Peter said:

> The Te Reo Māori one, it was some greetings and we decided that we would do it in Scratch so they had to programme Scratch. And then for those kids who were able [to], they could add their voice to it, so it was them talking and they were able to make it into a little movie for some of them. [We then shared] those to whānau [family], and we could share those to the community too in assembly.

Peter's plugged example of a culturally responsive approach to using Scratch software identifies how teachers can provide activities with different opportunities to center their students in CT practices. Peter also discussed how using Scratch assisted his classroom practices. He stated:

> They [the students] actually find it a bit more interesting and it's just a different way for them to learn, a bit more tactile.

Both teachers in our study commented on how knowing their students well impacts their teaching. This knowledge included understanding their students' culture, likes/dislikes, things that motivate them, and how they learn. Scott et al., (2015) argued that utilizing culturally responsive teaching in classrooms encourages teachers to reflect and connect with their students. In addition Gay (2010) stated that teachers who are culturally responsive

use their students' identities to develop lessons, and may form more sustainable relationships with their students (Ware 2002; Brown-Jeffy and Cooper 2011).

DISCUSSION

Te Kete Ipurangi[1] describes teaching and learning with a localized curriculum as weaving local stories and history into the student's learning. Because of this priority in the New Zealand Curriculum, there needs to be support for teachers to learn how to utilize a localized curriculum. Our two case studies show how teachers' beliefs about the importance of drawing connections between CT and students' lived experiences, support from schools, and opportunities for experimentation in their teaching allowed them to implement CT lessons that drew upon students' backgrounds and/or a local context. For example, Catherine had created curricula to integrate CT learning into pūrākau; specifically, stories and myths from the area where the students lived. Catherine became knowledgeable about the localized curriculum and spent a lot of time and effort creating resources for her school and felt supported by her schools' strategy.

Prior work within teacher professional development has suggested that there are four domains that influence teacher practices: the personal domain, the domain of consequence, the domain of practice, and the external domain (Clarke and Hollingsworth, 2002). These domains "constitute the individual teacher's professional world of practice, encompassing the teacher's professional actions, the inferred consequences of those actions, and the knowledge and beliefs that prompted and responded to those actions" (p. 951). Within our case studies, personal domain refers to teachers' own beliefs about culturally responsive ways of teaching and learning CT, domain of consequence refers to CT outcomes teachers care about for their students, domain of practice refers to opportunities to experiment in their classes, and external domain refers to factors outside teachers' control such as the school's strategic vision for implementing CRC. Both teachers in our study mention aspects of these domains that impacted their implementation of CT using culturally responsive pedagogies.

Furthermore, both teachers highlight the importance of contextualizing CT within their local community context by learning about students' cultures and language. Lachney and Yadav (2020) argue that a reason why CRC is less common in formal classrooms is because it cannot be easily implemented as predetermined steps, and must be responsive to locally situated contexts. If CRC includes pre-made curricula and tools, and that means standardization, there is a risk of decreasing specific computing-culture connections (Lachney & Yadav, 2020). The authors state one way to ameliorate this issue is to create connections between knowledgeable people outside the school system who provide information and insight into local history. Both Catherine and Peter drew on local expertise and resources to teach CT in a culturally responsive manner.

In Peter's case, his example aligns with how to use Scratch coding as a way to create meaning through constructing bilingual conversations in a language arts context (Vogel et al., 2020). Similar work by Vogel (2020) included co-designing CT-integrated unit plans with teachers using Scratch that were relevant to the students' experiences and language. For Peter, using Scratch to develop CT activities to learn Te Reo Māori also aligns with Vogel and Garcia's (2017) core components of translanguaging pedagogy. Specifically, he was drawing on students' linguistic practices that are valuable resources for their education and integrating students' in-school/community language practices to engage them in computational tools and practices. Finally, Peter discussed changing his instructional plans as he taught the lesson, based on student feedback of their interests and understanding his students. Vogel et al., (2020) argue that understanding students' various literacies and joining them with computational literacies using translanguaging can support students more equitably. In summary, Peter's use of Te Reo Māori in his CT lessons shows that "code is not something to be learned in a vacuum – and it certainly does not replace traditional language learning [and is used to] participate in broader computational literacies – to, in this case, have conversations about bilingual self-expression in a language arts context" (Vogel et al., 2020, p. 436).

In summary, our paper highlights how CRC approaches could be implemented in an elementary context by using community assets that could broaden participation, and also strengthen relationships between schools and communities (Lachney & Yadav, 2020). However, as Lachney and Yadav argue, teachers need support to engage their communities so they have the knowledge and ability to create CRC activities and units of curricula. In our case, the teachers' use of local knowledge and understanding where to find appropriate resources, provided them with information and curriculum materials related to integrating Te Reo Māori and pūrākau with CT.

IMPLICATIONS

Our case studies provide some evidence that supporting teachers through pedagogical resources and policies can influence them to adapt CRC approaches to teach CT. In particular, having school policies that prioritizes teachers to incorporate students' cultures and language into the

curriculum could shift whether and how teachers use CRC approaches into their own instruction. In order to increase the use of culturally responsive pedagogy to teach CT/CS, it is important that school leaders provide vision for their staff to prioritize incorporating students' lived experiences into their classrooms. However, it is not sufficient to just provide vision, teachers also need support that will help them develop necessary competencies to incorporate CRC. These supports require both materials for their own learning as well as access to expertise who can provide guidance on how to adapt CRC approaches into an existing curriculum. In addition, as Lachney and Yadav (2020) argued, we also need to build connections between school and communities that allow teachers to go beyond their classrooms to learn about students' lives and also create opportunities for community experts to inform what happens in the classroom. Future work should examine whether and how this bidirectional relationship could be fostered. Given that many computing curricula are top-down, we also need to provide on and off ramps for teachers to be able to center their students and communities in their instruction.

Our research also has implications for future research related to professional development, teacher knowledge, and student outcomes. Specifically, future research should examine the role of professional development in developing teacher competencies related to CRC.

Future research should also investigate the influence of CRC approaches on students' identity and belonging in computing learning experiences.

NOTE

[1] Te Kete Ipurangi is New Zealand's bilingual education portal which aims to provide information, resources, and curriculum materials to enhance teaching and learning.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Appendices.** Appendix 1 and 2. DOI: https://doi.org/10.26716/jcsi.2023.12.22.51.s1

ETHICS AND CONSENT

This project was reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 20/62.

COMPETING INTERESTS

The authors have no competing interests to declare.

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