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Culturally Relevant Pedagogies (CRP) and Culturally Responsive Teaching (CRT) in Science Education: Black Success Stories in Ontario

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Abstract The continued underrepresentation of Black students in science education in Ontario has highlighted issues of social justice within the province, and the ways in which this impacts minoritized groups, curriculum design, and teacher education. Critics of a post-colonial education system that reinforces existing biases against certain groups have pointed to culturally relevant and culturally responsive pedagogies for enhanced student success. The lack of attention to Black history, experiences, and perspectives in science has resulted in the needs of Black student populations being underserved. This small-scale qualitative study examines the self-reported pedagogies of three purposefully selected, successful science teachers, effectively utilizing culturally relevant and responsive pedagogies to improve Black student engagement and achievement in Ontario classrooms. Responses from participants recorded via Zoom using in-depth semi-structured interview protocols, along with additional notes taken in informal conversations, were inductively and deductively analysed. Three major themes emerged: successful teachers of Black students practice inclusion by incorporating Black references and experiences in classroom teachings, actively work to build empowering relationships with students and their caregivers, and are life-long learners, motivated and committed to supporting the academic, social, and cultural needs of their students. In addition, our findings suggest that science teachers, regardless of race, can promote Black student success through being critically reflexive practitioners and adopting culturally responsive strategies. As a result, these success stories can inform broader school administration policy regarding diverse student populations, and improve science teacher preparation and education programmes in Ontario and beyond.

Résumé La sous-représentation persistante d'élèves noirs dans l'enseignement des sciences en Ontario a mis en lumière les enjeux reliés à la justice sociale dans la province et les répercussions de cette situation sur les groupes minoritaires, la conception des programmes et la formation des enseignants. Les critiques d'un système d'éducation postcolonial qui renforce les préjugés existants à l'encontre de cer-

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tains groupes ont mis l'accent sur des pédagogies culturellement pertinentes et qui tiennent compte de la réalité culturelle afin d'améliorer la réussite des étudiants. Le manque d'attention portée à l'histoire, aux expériences et aux perspectives des Noirs dans le domaine des sciences a eu pour conséquence que les besoins des populations étudiantes noires n'ont pas été pris en compte. Cette étude qualitative à petite échelle examine les pédagogies signalées par trois professeurs performants de sciences sélectionnés à dessein et qui ont réussi, en utilisant efficacement des pédagogies pertinentes et arrimées à la culture à améliorer l'engagement et la réussite des élèves noirs dans les classes de l'Ontario. Les réponses des participants enregistrées par l'entremise de Zoom à l'aide de protocoles d'entrevues en profondeur semi-structurées, ainsi que des notes supplémentaires prises lors de conversations informelles, ont été analysées par raisonnement inductif et déductif. Trois thèmes principaux ont émergé: les enseignants efficaces auprès d'élèves noirs pratiquent l'inclusion en incorporant des références et des expériences noires dans l'enseignement en classe, ils travaillent activement à l'établissement de relations renforçant l'autonomie des élèves et les personnes qui en sont responsables, et sont des apprenants tout au long de leur existence, motivés et engagés à soutenir les besoins scolaires, sociaux et culturels de leurs élèves. De plus, nos résultats laissent présager que les enseignants de sciences, quelle que soit leur race, peuvent favoriser la réussite des élèves noirs en faisant preuve d'une réflexion critique et en adoptant des stratégies adaptées à la culture. Par conséquent, ces expériences réussies peuvent apporter des informations utiles dans la définition par l'administration scolaire de politiques élargies concernant les diverses populations d'élèves et améliorer les programmes de préparation et de formation des enseignants de sciences en Ontario et au-delà.

Keywords BIPOC · Black students · Achievement · Culturally relevant pedagogies · Culturally responsive teaching · Culturally relevant and responsive science teaching · Ontario science education

Introduction

The demand by education stakeholders for culturally relevant pedagogies and culturally responsive teaching to engage racially, culturally, and linguistically diverse students in public schools has been growing across the globe. Since 1995, Ladson-Billings has bemoaned that African American children are underserved in American and Canadian public schools, and there is also an increasing awareness that Black children often suffer from individual and systemic discriminations (Hayes, 2011; James & Turner, 2017; Maynard, 2017). In Ontario, for example, there have been calls for action to tackle systemic racism in the province's schools (Harris, 2020; Hayes, 2011). The populace is demanding that the education system address the inherent biases and structures inbuilt from its post-colonial origins to more adequately meet the needs of an increasingly diverse school population—a reality in Canada, especially in certain provinces like Ontario, Nova Scotia, and British Columbia. Additionally, Dei (1996) expressed concern about the shortage of Black teachers; the lack of attention given to Black perspectives, histories, and experiences; and the Eurocentric dominance of materials selected for inclusion in school curricula.

Particularly striking is the underrepresentation of minorities in science, technology, engineering, and mathematics (STEM) careers in the USA, UK, and Canada (DeWitt & Archer, 2015; Ramsay-Jordan, 2020; Singh, 2016). In England, minorities such as Black Caribbeans are noted for low participation in post-compulsory science education (DeWitt & Archer, 2015). These student minorities often face barriers such as inadequate resources, disparities in school funding (Ramsay-Jordan, 2020), lack of culturally relevant and responsive pedagogies (Caswell et al., 2011; Corneille et al., 2020; Krugly-Smolska, 1996), feelings of exclusion (Rainey et al., 2018), and even curriculum ambiguities

and gaps (Mujawamariya et al., 2014). These factors are compounded in science education by the view that science is value-free, with varying positions adopted by educators on how socio-political, historical, and other lenses may be applied in modern-day contexts (Pedretti & Nazir, 2011).

Culture, race, gender, and ethnicity concern researchers conscious of equity and access differentials for various subgroups such as Black, Indigenous, and People of Colour (BIPOC) (Aikenhead & Elliott, 2010; Carlone et al., 2014; Chrona, 2021; Krugly-Smolska, 2013). Critiques of the deficit lens through which minoritized learners are often viewed (Chrona, 2021), and of Western science education in general (Dodo Seriki, 2018; Krugly-Smolska, 2004), suggest a greater focus is needed on the broader issues of policy and curriculum reform for greater inclusion of minoritized populations.

Despite calls for equity and social justice in schools, and government mandates to incorporate multicultural perspectives into the curriculum, Black experiences and knowledge are yet to be fully integrated in the science classroom (Henry, 2017; Krugly-Smolska, 2013; Mujawamariya et al., 2014). Teachers are central to the success of their students. Eugenia Duodu, chief executive officer of the *Vision of Science Network for Learning*, reflected on the role supportive teachers played in her life as a Black girl from a low-income community in Ontario, in *The Unlikely Scientist* (TEDx Talks, 2018). In it, she explains how she overcame debilitating *imposter syndrome*, the crippling feeling of persons who second-guess their right to advancement and recognition, despite being high achievers, simply because they are female or belong to a minoritized population (Chrousos & Mentis, 2020). Duodo had been unable to believe that she, a Black female, had a legitimate right to a space in the field of science, or that she deserved to take her rightful place amongst fellow scientists. Eugenia is an inspiration. Unfortunately, there are far too many stories of Black students discouraged from pursuing academic paths in high school due to low teacher expectations (Maynard, 2017), especially when many, like Eugenia, question their right to be there based on their lack of science capital (Moote et al., 2021). As concerned educators and researchers highlight, many Black students are at risk of imposter syndrome, especially due to the lack of Black science teachers (James & Turner, 2017), females in particular (Mohorn, 2021). As such, schools play key roles in helping Black students overcome this negativity.

Culturally relevant pedagogies (CRP) and culturally responsive teaching (CRT) have been used effectively to reduce the achievement gap between Black students and their non-Black peers. In Ontario, work by researchers such as Lopez (2011), Caswell et al. (2011), Wane (2011), and West-Burns et al. (2013) have begun the work of addressing the needs of Black students using these principles in elementary education, mathematics, and the humanities. However, CRP and CRT as pedagogical models have lagged in science education (Dodo Seriki, 2018), disadvantaging some youths from scholarly pursuit in science. Specifically, the literature is quite silent on the use of CRP and CRT to increase participation of Black students in science. As a large proportion of Canada's Black population resides in the province of Ontario, with a substantial student population concentrated in the Greater Toronto Area (GTA), it is imperative that the province redress this. The percentage of self-identified Black students in Peel District School Board is a little less than 10% (Peel District School Board, 2020), while it is 12% in the Toronto District School Board (Yau et al., 2011). A report investigating the education of Black students within the GTA revealed schools showed a lack of interest in their specific cultural needs and a consistent relegation of Black students to the lowest academic streams (James & Turner, 2017). This means that Black students are less likely to graduate and to pursue science in the post-compulsory years, i.e. grades 11–12 (James & Turner, 2017), and are subsequently underrepresented in scientific careers (Singh, 2016). Even further, there appears to be a lack of acknowledgment of students' backgrounds and their funds of knowledge in current science teaching, thus leading researchers like Brown and Crippen (2016) to call for greater authenticity in science learning. It is hoped that programmes like *Science Teachers Are Responsive to Students* (STARTS) can lead to more culturally responsive teachers (Brown & Crippen, 2017).

Ladson-Billings (1990) acknowledges the importance of teachers' roles, and believes "successful teaching allows Black students to choose academic excellence without losing a sense of personal and cultural identity" (p. 337). She advises that culturally relevant teachers must assist students in being academically successful and culturally competent, and having a well-developed "sociopolitical or critical consciousness" (Ladson-Billings, 1995b, p. 483). Ladson-Billings and Henry (1990), on examining the practices of successful teachers of Black students in the USA and Canada, found that these teachers included an Afrocentric pedagogy in their practice, working dialectically between European and African ideologies, and remarked that "culturally relevant liberatory pedagogy is as much about relationships as it is about pedagogy" (p. 85). James and Turner (2017) mention that teachers and guidance counsellors repeatedly hinder positive school experiences for Black Canadian students. These authors also suggest that streaming, testing, and negative school climates have sustained anti-Black racism, which, in turn, negatively affects students' desire to excel. Fortunately, school districts in the province are working at de-streaming as a response to reducing systemic inequities.

The purpose of this qualitative study is to explore the effects of CRP and CRT through examining the practices of effective science teachers of Black students in Ontario. In this research, cultural relevance and responsiveness are defined as teaching philosophies which are student-centred, with classroom practices that use students' cultural knowledge, frames of reference, performance styles, and prior experiences to make learning encounters more meaningful and empowering for students (Chrona, 2021; Dodo Seriki, 2018; Gay, 2002; Ladson-Billings, 2009; McCready et al., 2011; Patton, 2011). The aim is to shed light on teachers' pedagogies and strategies that can contribute towards a model of effective science teaching for Black students by investigating these questions: How are Ontario's science teachers implementing culturally relevant and responsive pedagogies in ways that support Black student success in science? What is the nature of the relationships that effective science teachers have with Black students and their caregivers? Why are teachers of Black students motivated to implement culturally relevant and responsive science pedagogies?

Positions of the Researchers

In doing this work, the researchers, who identify themselves as BIPOC with Caribbean immigrant backgrounds, remained reflexive while observing Canadian classrooms and interacting with students and teachers in Ontario's schools. As researchers, we observed firsthand the conspicuous absence of Black students from senior high school science classes, and our attention was also drawn to the marginality and depersonalization of Black Canadian students. As educators, we sought to look more closely and to understand perspectives and practices implemented by successful teachers within our own communities in Ontario. We believe that this work can contribute meaningfully to a greater understanding of CRT and CRP and their effectiveness in multicultural societies like Canada. We also hope that our voices can be added to discussions supporting improvements in student outcomes and creating more equitable opportunities for Black students.

In the next section, we present a review of the literature on CRP and CRT, globally and in Canada, with a focus on Ontario. We examine gaps in science education and related challenges for BIPOC community members, with particular focus on Black students. We then close the section by highlighting the literature related to teachers of Black students, to ground our methodological decisions in the section that follows.

Culturally Relevant Pedagogy (CRP) and Culturally Responsive Teaching (CRT)

The frameworks of CRP (Ladson-Billings, 1995b) and CRT (Gay, 2002) provide the foundations for this study. Ladson-Billings defines CRP as pedagogical practice which "helps students to accept and affirm their cultural identity while developing critical perspectives that challenge inequities that schools (and other institutions) perpetuate" (Ladson-Billings, 1995b, p. 469). As a result of this and other works by

Ladson-Billings (1995a, 2009), CRP—describing practices which are culturally sustaining and which provide positive educational outcomes for Black students—has been proposed as a solution to the low academic attainment of African Canadian students (Henry, 2017). Similarly, Gay (1994) introduced the concept of cultural responsiveness in schools to populations that would more adequately respond to the needs of multiculturalism and diversity. While both concepts have much in common, Ladson-Billings (1995a, b) focuses on the building of cultural competence through retention of a Black identity.

Gay (2002) defines CRT as a process of "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (p. 106). She proposes that aspects of CRT are socially and academically empowering; multidimensional; validating every student's culture; socially, emotionally, and politically comprehensive; transformative; and emancipatory (Gay, 2000). From this perspective, CRP and CRT require teachers to effectively integrate and utilize the rich source of cultural knowledge, experiences, expressions, and frameworks which students bring to the classroom. Gay and Howard (2000) furthered notions of the cultural relevance of students' backgrounds as multicultural education, and called for pedagogies to adapt to ethnically diverse students that utilize their cultures in the teaching–learning process. Paris and Alim (2017) build on these ideas and argue for culturally sustaining pedagogies which seek to make schools harmonizing places of learning, rather than places which eliminate the languages and identities of students. They strongly argue for ideologies that critique traditional structures and ways of knowing, and offer pedagogies that shift the balance of power within education. Their work has sought to extend the foundations laid by Ladson-Billings, which she embraces as a natural part of the socio-political critique, growth, and evolution of new theories and ideas (Ladson-Billings, 2014).

CRP and CRT in Science Education

Over the last 20 years, major thinkers have offered shifting perspectives on science curriculum, from knowledge of science, to scientific, cultural, and civic literacies. Aikenhead (2006) focuses on values and social responsibility in science, while Hodson (2010) calls for a more socio-political lens, with an emphasis on the criticality of school-based activities. Dodo Seriki (2018) advises science educators to engage in critical self-reflection, and to adopt CRP and CRT for diverse student populations, as "an educator cannot hold a deficit-orientation towards students while engaging CRP" (p. 98).

There are few studies that apply CRT and CRP to the teaching of science, perhaps due to the common perception that science is objective and devoid of bias (Le & Matias, 2019). Tanase's (2020) investigation of the use of CRT in 22 math and science classrooms in Florida revealed a variety of student-centred strategies such as discovery learning centres, group work, and games. They found clear evidence of CRT through incorporation of students' culture. The notion of encompassing the cultural perspectives and frameworks of BIPOC populations is strengthened by Aikenhead's (2001) work on cross-cultural science education. In particular, he reported success in integrating Western and Aboriginal sciences in Saskatchewan.

CRP and CRT: Empirical Work with Science Teachers in Canada and the Science Education of Black Students in Ontario

In Ontario, culturally relevant and responsive pedagogy has been integrated into teacher preparation programmes at leading universities (McCready et al., 2011; West-Burns et al., 2013) and in practitioners' approaches (Krugly-Smolska, 1995; Lopez, 2011; Wane, 2011) due to increased diversity of school populations; however, there are few empirical studies which highlight Black students.

In Vancouver, Parhar and Sensoy (2011) studied how ten teachers met the needs of culturally diverse students. They all purportedly believed in the tenets of CRT and CRP proposed by Ladson-Billings

and Gay, and claimed to be working to empower students and help them succeed, regardless of race or background. In the article, the authors acknowledged the many challenges in successfully implementing all the tenets in different schools, thus highlighting the need for institutional and structural reform. While details were given on the backgrounds of the teachers, none were science specialists.

Meanwhile, in Toronto, McCready et al. (2011) reported on the application of culturally relevant and responsive teaching and pedagogy in selected secondary urban schools. The research was based on Ladson-Billings' three-pillar framework of academic success, cultural competence, and critical consciousness (Ladson-Billings, 1995a). They found that, although measuring secondary teachers' cultural competence was difficult as the notions of culture itself were so complex and nuanced, teachers saw the value of infusing their curriculum with CRP and CRT content and practices. Unfortunately, the study did not specify the curriculum areas to which those teachers belonged. Caswell et al. (2011) placed focus on teacher candidates' development of strategies and pedagogies in mathematics with a social justice focus. Teacher candidates employed strategies considering students' cultural backgrounds and focused on equity-oriented mathematics. Meanwhile, Lopez (2011) examined the impact of CRP in diverse English classes with two secondary teachers. They identified pedagogies and strategies that allowed for high student academic performance and engagement. Strategies included culturally relevant texts, a caring approach, and the provision of students with extra assistance and time. Teachers promoted student success through critical inquiry into their own pedagogy and building cross-cultural understandings. Wane (2011) explored the ways that four elementary teachers in Toronto used an Afrocentric approach to help students understand themselves and the lost cultural identity of African ancestry. She found that a lack of resources impeded teacher success, and argued for recognition of each student's identity and for the freedom that teachers must have to bring a critical lens to their work for cultural relevance to succeed.

The works of Krugly-Smolska in Canadian school systems highlight an ethnocultural focus on student achievement (such as Samuel et al., 2001) and in science education specifically (1995, 1996, 2013). Krugly-Smolska (1995) examined Canadian classrooms in Ontario for differences in achievement in science among ethnic minorities. She observed three grade 9 science classes with diverse student populations, and examined specific cultural influences on the delivery of science education. She found "no recognition of the multicultural context in the science classroom, whether through teaching methodology, evaluation, or choice of samples for analogies. The most common response was one of evasion of the issues" (p. 51). The study revealed that Asian students were doing well, and West Indian (Caribbean) students were not far behind. Samuel et al. (2001) found similar results among selected ethnocultural groups in Toronto and Vancouver, though not specific to science. Notably, these results differ from those in the literature from the USA and England. In fact, students labelled as *Canadian* did worse academically than all other groups. Krugly-Smolska (1995) concluded that the influences of minority cultures can impact positively on student attainment, and called for further work on the relationships between culture and science learning. She asserted that migrant students' prior science knowledge and the cultural emphasis on science excellence in home cultures are keys to understanding minority student experiences in science, though no specific reference was made about Black students. Krugly-Smolska (1996) advises that science teachers need to recognize that every classroom is multicultural, even if it appears mono-cultural due to individual cultural variations. She suggests that once science teachers recognize the plurality of their classrooms, "minor changes in teaching strategies can make their classrooms inclusionary" (p. 27).

In another study, Mujawamariya et al. (2014) examined Ontario science curricula, grades 1 to 10, for aspects of multiculturalism, anti-racism, and inclusivity. They found almost no adjustments in curriculum planning or recognition of cultural knowledge which reflected the diversity of the student population. The curriculum still maintained Eurocentric perceptions in the ways in which science was taught, and, unsurprisingly, "minority students [were] excluded, disregarded, and made invisible in a

universal and color-blind curriculum, while the culture, behaviors, and perspectives of the dominant cultural groups remain viewed as natural and universal" (Mujawamariya et al., 2014, p. 280).

These studies, by Krugly-Smolska (1995) and Mujawamariya et al. (2014), reveal that neither the curriculum nor the classroom practices of science teachers sufficiently embrace the plurality and realities of the Ontario science classroom, and that Black students may suffer from a perceived neutrality of science curriculum and lack of criticality to teachers' own pedagogies. The dearth of literature on pedagogical models of CRT and CRP that address the needs of BIPOC students in the science classroom, with special emphasis on those with Black identities, drives the purpose of this study. The next section describes the qualitative approach we took in this study, outlining our methodology and interviews with three successful science teachers of Black students in the greater Toronto area. We follow this section by presenting the main themes in our findings and discussing these themes in relation to the literature. We conclude the study with limitations and recommendations for future work.

Methods

This small-scale exploratory qualitative research study was approved by a large Canadian university and undertaken by the first author in partial fulfilment of her teacher-education degree. The second author acted as instructor and, later, co-author for the project, which involved teacher participants from the greater Toronto area. The study aspired to understand the underlying structures of pedagogies which exemplify CRT and CRP, primarily sourced from in-depth interviews with three successful teachers of Black students in Ontario schools. Using an interpretive paradigm (Thanh & Thanh, 2015), a comprehensive understanding of participants' perceptions and self-reported practices was sought.

Using purposive snowball sampling (Kamalodeen & Jameson-Charles, 2016), teachers were recruited through recommendations from their colleagues and school administration. Out of the recommendations, teachers were selected using protocols extracted from works by Ladson-Billings (1995b), Foster (1997), and Hayes et al. (2014). Specifically, referees were asked to recommend teachers using the following guidelines: Black students do well academically in these teachers' classes and feel included, teachers communicate high standards and expectations to Black students, teachers validate the cultural identities of Black students in their classroom practices and instructional materials, and teachers have good relationships with Black students and their caregivers. These three teacher participants each had more than 10 years of teaching experience, and were considered proficient in their field (Varrella, 2000), with sufficient time to have developed their individual pedagogies. We obtained data saturation with three participants, as the small sample had information power (Malterud et al., 2016) due to the specificities of the study, expertise in the area of study, and engagement in rich dialogues with the interviewer. The pseudonyms Santania, Stan, and Tyra were assigned to participants to protect their identities. It is interesting to note that, although the referees of the participants were all from the Black community, the recommended participant teachers represented three different ethnicities: Black, White, and South Asian.

School and Participant Profiles

All participants were grades 8–12 teachers, as this included the compulsory years of science (Krugly-Smolska, 1995), and the optional senior years, grades 11–12, of high school (Ontario Ministry of Education, 2022a, b). They represent one elementary and two secondary school teachers who taught at least one class of 30% Black students. The participant schools were all from the same Ontario school board, where the Black population is higher than 5%. At least 50% of students at each school identify as Black, thus ensuring a higher likelihood of Black students in science classes.

Stan is an African Canadian male who grew up in Africa and self-identifies as Black. He completed his undergraduate education outside of Canada. Stan immigrated to Canada as an adult and did his master's degree and teacher training at Canadian institutions. He has been teaching for more than 12 years, and in his current position teaches science to grades 9 and 10 and physics to grades 11 and 12. He believes "hard work is the key to success" and works to be a role model to his students. Stan uses storytelling to motivate his students, build relationships, and illuminate difficult concepts in science. This is a product of his cultural background as an African Canadian.

Tyra self-identifies as a South Asian Canadian female, with international qualifications. She completed her teacher training outside of Canada and was already an experienced teacher when she immigrated. She has been teaching on and off for 30 years, and science is one of several subjects she teaches to grade 8 students. Tyra seemed motivated by a desire to be an effective educator, and mentioned doing continuing education courses and consulting the research literature to improve her practice. She aspires for all her students to succeed using differentiated instruction principles to achieve inclusion in her science classroom.

Santania self-identifies as a Caucasian Canadian female who grew up in Canada in a predominantly White neighbourhood. Santania seemed motivated to see Black students and their families succeed based on the social justice and equity lens through which she views the world. Conversations with her frequently involve equity-seeking groups and acts of allyship. Her first real experience dealing with people of African heritage was in her practicum. She did her undergraduate, graduate, and teacher-training degrees in Canada. Santania has over 12 years teaching experience, and in her current role teaches science to grades 9 and 10 and physics to grades 11 and 12. Santania is an active member of her teachers' union and works closely with the CRP division of her school (Table 1).

Data Collection and Analysis

Semi-structured interviews allowed participants the space and time to elaborate on salient points while also allowing us, as researchers, to explore both the complex and subtle phenomena (Denscombe, 2014) related to teacher beliefs, attitudes, and pedagogies for Black students. Interviews were done online using Zoom during the pandemic lockdown. Though online interviews limited researchers' access to informal communication (Creswell & Poth, 2016), it also eliminated travelling costs, increased flexibility in interview scheduling, and facilitated ease of transcription and protection of participant identities as no cameras were used. To maintain the anonymity and confidentiality of participants, pseudonyms were applied to screen names, and cameras remained off during the entire interview process, which lasted approximately 60 min for each participant. Prior to the interviews, participants were sent invitation letters and consent forms to sign and return. At their requests, they were sent the interview questions, and interviews were conducted at mutually convenient times. Dialogues were audio-recorded, transcribed to text using Zoom, and edited. Afterwards, they were checked by participants for fact and intent and, out of ethical considerations, kept on a password-protected computer to maintain privacy. Questions for the interview protocol were informed by the study carried out by Ladson-Billings' (2009) work with successful teachers of African American children and Gay (2015, 2018) in her work on CRT (see *Summary of Interview Protocol* at the end of this section).

Forty-four (44) pages of transcribed interviews were generated and coded iteratively, using a combination of open, in vivo, and descriptive coding, to identify the emerging themes from these statements (Saldaña, 2013). Coding iterations were carried out manually on paper and electronically using Google Sheets, Microsoft Word, and the coding software NVivo 12 Plus for Windows. With each iteration, codes were reduced until only 23 remained. These codes were further merged into nine categories, from which themes were extracted. Analytical codes included motivation/commitment, elements of inclusion, and relationship building. Both researchers were involved in generating the codes. The first author did the

Table 1 Summary of participant profiles

Name	Gender	Race	Teaching experience	Educational qualification	School context	Science classroom context
Stan	M	Black	Teaches science in grades 9–10, senior-level physics, > 12 years teaching in Canada	International undergraduate and Canadian master's degrees, Canadian teacher-training degree	Ontario high school with > 50% Black students	80% Black students grade 9; 10% grades 11–12
Tyra	F	South Asian	Grade 8 science elementary, teaching > 30 years	International undergraduate, continuing education, and teacher training	Ontario elementary school with > 50% Black students	~30% Black students Grade 8
Santania	F	White	Teaches science in grades 9–10, university science grades 11–12; > 12 years teaching in Canada	Undergraduate and master's degrees from Canadian universities; Canadian teacher-training degree	Ontario high school with > 50% Black students	10–30% Black students in grades 11–12

Pseudonyms have been assigned; self-described gender, race, and science classroom contexts

initial coding while the second author oversaw the process using NVivo. This was followed by discussion and consensus influenced by the research questions, transcripts, and related literature. In this way, agreement of the codes was established.

The data used in this study included both interview transcriptions and personal notes taken informally during telephone and online conversations with the participants to clarify and expand questions arising from the interviews. Thematic analysis of the data was carried out using a combination of inductive and deductive approaches, the former because the raw data was reduced to yield summary categories and themes and the latter because answers were sought to specific questions based on previous research (Elo & Kyngäs, 2008; Thomas, 2006). Rigorous and systematic analysis of all transcripts yielded three major themes which were crafted and refined using the research questions and relevant literature. The personal statements of the participants in this study could have been enhanced by classroom observations to capture teachers' pedagogies firsthand; unfortunately, this was not possible.

The purpose of qualitative inquiry is to provide the researcher with a deep understanding of the issues and contexts related to the research, rather than replicability or generalizability (Butler-Kisber, 2010). In this case, our goal was to understand the factors involved in engaging Black students in science in order that they might achieve academic excellence and be represented in senior high school science classes and, subsequently, in scientific careers. Themes from this research can be used to inductively generate models of CRT and CRP which could be used in similar contexts. Throughout the study, we added details to procedures to augment the credibility and reliability of the paper, and remained critically reflexive, with our positionalities declared throughout the process.

Summary of Interview Protocol

The first four interview questions sought to establish who the participants were; demographic data on gender, ethnicity, years of teaching experience, and grade levels taught were captured to establish a culture of reference for each individual (Ladson-Billings, 2009). Other interview questions sought to elicit clear instances of culturally relevant pedagogies and responsive teaching through participants' personal statements. For example:

> *Have you taken specific actions in the classroom to facilitate the academic success of Black students? (Probe: Can you describe these actions*?)
> When considering student achievement in your classroom, what made you focus on improving the achievement of your Black students? Give examples.
> How does the science curriculum help you to support diversity in the classroom? Do you have certain images of successful science students? Are any of these students Black?
> If you could remodel teacher education so Canadian teachers are more effective with Black students, what changes would you make?

Findings

Emerging from the data analysis, we found three main themes: successful science teachers practice inclusion by incorporating Black references and experiences in classroom teachings, actively work to build empowering relationships with students and their caregivers, and are lifelong learners who are motivated and committed to student success. We have chosen representative statements based on the transcribed data from participants to reflect and illuminate each theme, in answer to our research questions.

Theme 1: Inclusive Classroom Environments That Honour and Respect Black Students' Culture Despite Curricular Shortcomings

Successful culturally relevant teachers use inclusive pedagogies and practices that honour and respect Black students' culture and identities in the classroom (Gay, 2000, 2002; Ladson-Billing, 1995a, b, 2009). They sustain and enhance cultural diversity, address gaps in curriculum, and include resources and models—such as virtual science labs in online sessions—in promoting equity. They do not shy away from difficult conversations. Instead, they give students a chance to respectfully express their views while they listen, support, and positively affirm. Throughout their narratives, participants described their validation of Black student identities through inclusion of Black culture and texts, affirming speech, recognition of effort, and encouragement.

Curriculum Adaptation to Include Black Culture and Texts

Tyra, the grade 8 teacher, is responsible for teaching multiple subjects. She therefore has the flexibility of introducing Black contributions in non-science areas of the curriculum, which she leverages to create a welcoming space for Black students in her classroom. She recounted including movies and documentaries that portray Black culture in a positive light in her classes, such as *Akeelah and the Bee* (Atchison, 2006) and *Hair Love* (Cherry et al., 2019). She also described how she uses group work and hands-on activities in her classroom, because she noticed her Black students were helpful to each other, worked well together, and had "a lot of energy and enthusiasm to learn". She commented that Black boys tended towards rivalries, and sometimes got into fights, but that they understood the limits she imposed as part of the classroom rules, so she did not have classroom management issues. She spoke about exploring the contributions and successes of the Black community throughout the curriculum. She noted the absence of Black contributions to the creation of Canada in the curriculum, and suggested that teachers make a concerted effort to incorporate their inclusion. She shared that she was currently teaching the topic of *cells* in her science class and highlighted Black scientists who helped with breakthrough research to provide representation. She also mentioned making "Black people and culture visible in math word problems" and using photographs representing Black communities and culture to motivate Black students to engage with lessons.

Both Santania and Stan reported that the science curriculum, especially the senior years of grades 11 and 12, provides few opportunities to include Black contributions, experiences, and knowledge. This task is left to the creativity of the individual teacher. Santania's disappointment in the offerings of the curriculum was expressed in her statement "The curriculum opens the doors, but you have to see those doors and you'll have to run with it on your own, as opposed to the material being provided." She admitted there was more flexibility to include non-Eurocentric perspectives in the grades 9 and 10 science curriculum, but even there it,

> doesn't do a good job of facilitating some of those conversations…it opens it up, but you as the teacher have to, (1) find the article you want to discuss, [and] (2) the teacher has to be confident enough to have those conversations.

As an example of providing students choice in what they were learning, Santania cited a career assignment where she asked students to pick a scientist they resonated with and explore their educational trajectory. She related how she allowed and encouraged students to participate whenever there was an invited school guest from the Black community, to inspire students to greatness. Like Tyra, she shared some of the texts she used which include Black voices. She excitedly shared her recent acquisition, *Black Women in Science* by Kimberly Pellum (2019), which highlights the achievements and contributions of Black female scientists. She expressed how she saw herself reflected in the stories of these women as

someone who identifies as a female scientist, and relayed her belief that young Black girls aspiring to be scientists would be similarly inspired and encouraged.

According to Stan, he uses his personal knowledge of Black contributions acquired from his upbringing and education in a Black majority country, along with his lived experiences, to address the gaps in the curriculum. He reported frequently citing examples of industrial success from the Caribbean, where most of the population is of African descent, to encourage Black students, letting them know that their people have also made significant scientific contributions to current understanding of the world. Participants also described practices such as the use of traditionally Black names in worked examples and practice exercises, in recognition of the need for Black students to see themselves reflected in their learning.

Throughout the narratives, the participant teachers described not having enough support from the curriculum in addressing the needs of Black students for representation, ways of knowing and doing, and scientific contributions. Santania poignantly mentioned, "I'd love if they had even at the end of the curriculum of the stuff like suggested reading… I would love for them to have like a reading list or even a list of scientists somewhere". According to Stan, teacher knowledge relies on "collective experiences that [they've] gained over the years talking to different issues and [their] own personal experiences… talking to [their] colleagues" which has helped them to figure out some of the challenges.

Affirmation, Encouragement, and Listening

Throughout the interviews, the participants related how important it is for Black students to be consistently, positively, and authentically affirmed. Tyra commented on the importance of being kind and supportive of Black students as she found,

> A lot of the times they are reluctant to even accept the praise that you might be giving them, the accolades, or maybe at times they come up with certain ideas, they are reluctant to talk about it.... the support that you bring in with you…kind words, kind ways of approaching student[s] and their problems… is really important.

Stan related drawing on the African penchant for storytelling, a gift that has survived even within the diaspora, to engage and motivate students. He described creating a happy class atmosphere and boosting the morale of his students by creating fictional characters like "Little Johnny". He imbues Little Johnny with the characteristics he wants to see displayed in his students, to lighten the mood while communicating his maxim "train hard, win easy". As he explained, "Little Johnny needs to work very hard in class today, Little Johnny's happy, Little Johnny's gonna complete this work and it's a journey. He's gonna make sure that high energy is exhibited in class today." His students connect with Little Johnny, becoming contented and relaxed enough to achieve academic success.

Throughout her interview, Santania spoke about the need to listen to Black students and validate their concerns about what they are experiencing. She reported letting students know that "I'm here and I'm receptive to whatever you're experiencing, if you feel like sharing it with me." She explained that this invitation needs to be given with sensitivity to communicate authentic care for students.

Theme 2: Teachers Build Strong Relationships with Black Students and Their Caregivers

Findings from all participants showed that building strong, empathetic relationships between teachers and students, and teachers and caregivers is possible and results in Black student academic excellence. They emphasized communicating genuine care and empathy towards students, and constant and persistent communication in building trusting relationships with caregivers. In general, the findings show that building relationships with the Black community demands time, effort, and commitment from teachers, due in part to the historical mistrust between the Black population and the education community, and

the fact that many teachers in the classroom neither share nor understand the ethnicity and culture of Black students.

Trust and Open Communication Between Teachers and Students and Caregivers

Santania related being intentional in building trusting relationships with caregivers through community connections. She is aware she does not share the ethnic and cultural identities of her Black students, but openly declared a willingness to learn. She spoke of supporting the school's CRP team, and continuously seeking opportunities to address students' needs. She contended, "…as someone who is not Black, I haven't lived a Black experience, but I am more than happy to help support and encourage growth within the Black community in any way, shape or form that I can." She outlined her strategy of getting to know Black students and their culture by volunteering for extra-curricular cultural activities, and maintaining relationships with them outside of school, even after they graduate. She explained, "I've been to weddings, I've been to baby showers, and I think having that community and finding that support both in the class and extracurricularly [is helpful]." She offers herself as a willing and committed ally to her Black students, saying of them,

> I think that there's a lot of issues with feeling like they belong and feeling like they're welcomed in classrooms, and feeling sort of a trust with the system and the teacher in front. I think that is a relationship that can sometimes be a bit harder to build based on the experiences, unfortunately often negative, that they've experienced in the school system or in the broader community.

Santania reported forging relationships with parents, caregivers, and others who actively support the achievement of higher educational outcomes for Black students. She recounted keeping caregivers abreast of student performance, aiming to increase discussions of academics at home. She explained, "I also think it's really important that families, when they're having conversations around the table, are able to have conversations about the school system, so engaging parents in the broader school community."

Santania described one of her strengths as the ability to really listen to Black students, although she was quick to add she tries her "best with every single kid". Of herself, she says,

> I'm open to hearing and listening to the information that students are willing to provide… what they feel like has held them back, what they feel like they need to move forward in a really big kind of growth way, with respect to the curriculum and their educational pathway… I think that if you are willing to listen to a student they understand that you care about them as a person, you don't just see them as a number …or a body in a room. You see them for who and what they are, and what they're able to bring. And if you are willing to listen and give each kid the time and the independence to let you know what they think, and what they need, you can respond accordingly… that's when really big change and a really good strong relationship within the classroom can be built.

Stan, on the other hand, is conscious of his shared identity with Black students and described how this facilitates their confidence and trust in him as an educator and role model. In explaining his position, he said, "I'm a Black teacher, [I] have to connect back to [my] own lived experience on how [I] get to that point, and share that story with them…." Throughout the interview, he described his care and empathy for students, especially Black students. Like the other participants, he too expressed that students know and sense your care, or the absence of it, and respond accordingly. As Santania described it, Black students are "amazing at sort of reading through smoke and mirrors".

Stan considers himself an exemplar and role model for his students to emulate, and works hard to live up to their expectations. He explained,

> I want them to see me as a role model, to say, "oh, if this person can do this, I think I can do better." And the only way you can make that happen in their mindsets is to be able to deliver very well.

He also shared how he deliberately works to keep the communication lines open between himself, his students, and their caregivers, relating the gratitude of parents to have someone from the Black community in his position.

> I think I will rank [my relationship with parents] very well because they can connect more with what I do and say, and how I relate to them in terms of their child's performances. I think they are very grateful I'm putting in [all the] positive energy to make sure their kids succeed.

Stan shared he has a three-step pathway to building relationships with students and caregivers: introduce himself to the class and to caregivers as the science teacher so they know they have someone to talk to, follow up with a parent-teacher interview, and make sure that the image parents have of students at home is the same as the one presented at school. He clarified the latter, saying that sometimes students try to fool either the teacher or the caregiver, so it is important that everyone is on the same page in terms of student behaviour and performance. He pointed out that some Black parents are not easy to reach because of their job situation, but nevertheless, he persists and reassures them he will work with them to ensure the success of the student.

Tyra placed heavy emphasis on open and constant communication with caregivers, and emphasized her role in building connections with them. She spoke of her duty to open communication lines and consistently keep caregivers updated with students' progress. She explained,

> I connect with my parent community through emails, phone calls, and in person meetings… It's part of my accountability that I report my students' success to parents regularly and consistently. Due to my constant communication, we develop a trusting relationship and parents feel safe to discuss all aspects of their child's learning journey.

According to her, maintaining trust between herself and students' caregivers creates a fertile environment for student success. She explained she is especially motivated to focus on Black students when their parents are either too busy or unable to help with support at home. She described the role of caregivers as integral to students' success, confidence, and hope, and cites this as the reason for her perseverance in developing these relationships. She explained,

> I start off with opening lines of communication, multiple lines of communication with parents, and there are lots of parents I don't get for months, but with persistence you know, just going on and on with emailing and calling them up, [because] I think all parents innately, like naturally, want success for the kids.

She went on to say,

> They may not have the time to help and support as much as is expected, or as a child might be needing, but when the teacher is persistent, really trying and trying and not giving up, they come around. Then they start to help and provide support.

School Support

From the findings, we also noticed that our successful teachers were situated in schools where they felt supported in their efforts towards students. As Tyra described,

> We have a lot of agencies working with our school… we have a very resourceful principal; she gets a lot of help from around. We have different programmes…supporting our students in so many different ways. At the beginning of the year, we gave out backpacks, stationery and pencils and calculators.

She also described her school being part of the Ontario Focused Intervention Partnership which facilitates tutoring for students. She described her institution as "an amazing school".

Santania and Stan also work in schools which actively support Black student success. Santania spoke of her relationship with the CRP team, and described the CRP resource teacher as "doing amazing work with the BSA [Black student association]" and someone she has learned a "a ton of things" from. She expressed her appreciation for the opportunity to grow in her understanding of the needs of Black students as a White person who grew up in a predominantly White community and did not share their lived experiences.

Theme 3: Commitment to Black Student Success

It is important to note that all participants commented that Black students' performance in their classes was no different from the performance of other students, except at the post-compulsory level where their numbers were few, and that they performed exceptionally well in science. Each participant held a self-reported commitment and dedication to successful outcomes for Black students and their families, though their motivation came from different angles based on their individual contexts and unique lived experiences. They all described establishing high standards in their classrooms, having high expectations of students, and holding the belief that all children are unique and valuable and should be viewed as individuals; they also appear to care about and are empathetic to Black students. The unique individual commitments to Black student success we identified from their narratives were as follows: equity and social justice, shared Black identity, and a strong personal desire to see all students under their care achieve.

High Expectations

Interestingly, when asked, the participants said there were no noticeable differences in academic performance between their Black students and their non-Black students in grades 8–10, but found Black students to be more outstanding in grades 11 and 12. Stan believes that the culling of Black students from senior science has resulted in this observation.

When asked to comment on the characteristics of a successful student, Santania explained that there was a lot of diversity in student expression,

> I have had successful kids where they were living on their own, and I've had successful kids where their parents were very involved… I've had really successful students that never asked a single question. I've had really successful students that have asked tons of questions… Success can kind of come from anywhere, it can look like anything.

In general, the participants agreed that Black students do well in science when their teachers have high expectations of them, they are supported, and their efforts are recognized.

Throughout the interview, Tyra spoke of having high expectations of students, and that, when she spots academic potential, she puts all her energy into supporting and nurturing it. She spoke passionately of a Black student who has the determination and ability to do well in science, but lacked the confidence to aspire to regional programmes which cater to students pursuing more challenging academic pathways, possibly leading to scientific careers. She spoke of her gentle persistence in planting the seed within the student to aspire to an advanced placement programme. She remarked that this lack of confidence and reluctance regarding their abilities is noticeable among Black students, and advised teachers to be kind and supportive. She stated that many times "they [were] reluctant to even accept the praise that you might be giving them, the accolades, … even when they come up with certain ideas they are reluctant to talk about it."

Social Justice and Equity

Santania seemed motivated to see Black students and their families succeed based on the social justice and equity lens through which she views the world. Santania described playing an active role in school politics. Her activism, work with the CRP unit and Black Students Association, close relationship with the CRP resource teacher, and participation in community and school activities all indicate her willingness and commitment to learn and grow in her understanding of the community. Throughout the interview, she mentioned Black and Indigenous students as individuals worthy of expressing themselves in unique ways, without judgement or discrimination. Her seeming empathy for students who encounter racism and marginalization, frustration with the incremental changes that are happening, and determination to make a difference were expressed as follows:

> …like I saw firsthand how sometimes students felt … I learned that early on, but 10 years later the fact that kids still feel like that … kind of made me sort of double down …wanting to participate in the school team, supporting the CRP teacher …with the BSA [Black Student Association].

Santania gave credit to her experiences as a pre-service teacher for her respect and positive perceptions of Black students. She recounted how treating students respectfully and having them return that respect during her practicum was a life-changing experience which initiated her journey to gain knowledge about the needs of the Black community. She recommends that non-Black teacher candidates be provided with similar opportunities, but warned that teachers must be authentic, as Black students can be particularly sensitive to teachers' perceptions and expectations of them, and react negatively to deficit perspectives.

Commitment to Being an Effective Teacher

When compared with Santania and Stan, Tyra seemed less attentive to the discourse surrounding the racial dynamics of the Ontario classroom. She showed reluctance to personally identify students as Black, preferring to have her students self-identify. Without mentioning racial tensions and deficit perceptions of Black students, she gave the impression that if a student were in her class, it was her personal mission and obligation to see that the student was successful. From dialogue with her, we concluded that student success was her success, or as she summarized it, "success for one, is success for all of us". Several times throughout the interview, she mentioned differentiation of instruction as her solution to obtaining positive learning outcomes for each student and the main thread throughout her teaching philosophy. Her narrative gave the impression of a reflective practitioner and a self-identified lifelong learner, who is constantly working to improve her practice by addressing points of inquiry with current educational research. She commented on the observations she made of her students, such as their need for kinesthetic activity, and how she uses these to enhance her practice. Tyra was described by her referee as an exceptional teacher whose personal work ethic is beneficial to her Black students.

The teachers, all of whom attended teacher's college more than 12 years prior to the study, reported the absence of CRP courses in their teacher preparation. They also reported inadequate amounts of professional development opportunities on the topic. Despite this, all the teachers described making deliberate attempts to include Black contributions, knowledge, and experiences in their practice and in their quest as lifelong learners.

Discussion

This study was designed to highlight what successful teaching of Black students in science looks like. Our participants were selected because others believed they exhibited the characteristics of successful

teachers of Black students. These teachers were prepared for integrating CRP and CRT in their science classrooms through engaging with the Black community, seeking out professional development opportunities, engaging in professional learning communities, and procuring resources which highlight Black achievements and portray Blackness positively.

By reviewing the research questions that guided this small-scale qualitative inquiry, we sought to discover what culturally relevant pedagogies were used, and how teachers responded to Black students in their classrooms, by organizing the collected data in the highlighted themes. We found that teachers employed various pedagogies such as culturally relevant texts, examples, and stories in their classroom through purposeful adaptation of the science curriculum. While they bemoaned that the curriculum was inadequate as a guide, they suggested supportive school administration and support helped them to adopt creative strategies to spur Black student excellence. Secondly, we learnt that the teachers placed high value on connecting with students inside and outside their schools, and on building trusting relationships with students' families. This occurred regardless of the race of the teacher. Thirdly, we looked at teacher motivation and found out that these teachers did not have differing expectations of Black students versus other students, but had high expectations for all students, giving extra support and help when needed; most importantly, these teachers held high expectations of themselves, suggesting high self-efficacy.

These findings suggest a confluence of factors that can positively serve Black students in science classrooms and help them to advance to higher levels of studies. We suggest that the teaching pedagogies highlighted here as CRP are simply good teaching (Tanase, 2020); however, we wish to underscore the importance of the science curriculum and teacher preparation in adequately preparing and supporting teachers whose everyday lives involve classrooms with diverse populations. There is enough evidence on the gains in performance for Blacks and other minorities when they see themselves reflected in the curriculum (Ladson-Billings, 2009, 2014; Mujawamariya et al., 2014). Teachers were not hesitant to speak to curriculum gaps, and our study suggests that the science curriculum continues to be dominated by Eurocentric ideas, behaviours, and assumptions (Aikenhead & Elliott, 2010; Carlone et al., 2014; Chrona, 2021; Dei, 1996; Krugly-Smolska, 1995; Le & Matias, 2019).

The participants all commented on the lack or insufficient quantity of CRP training in their teacher education programmes and in subsequent professional development, and expressed their desire for teacher preparation to include CRP and CRT in meaningful ways. Since their article in 2013, West-Burns et al. have been recommending greater attention to equity in education. Additionally, since 2011, several teacher educators such as McCready et al. and Lopez have worked with Ontario teachers to measure and improve understandings of CRP.

Participants recognized the need for teachers to use group work, movement, and hands-on activities in teaching science to Black students (Carter et al., 2008; Hawkins, 2005; Ladson-Billings & Henry, 1990; Parsons, 2003). The research disclosed that Black students thrive in group work, as they were willing to work and support each other. This dimension of communalism (Carter et al., 2008) illustrates the Ubuntu philosophy, "I am because we are", common among people of African heritage. If science teachers include more hands-on activities and group work in classes, then Black students will be included and other students will benefit (Aikenhead, 2006; Parsons, 2003). The teachers in our study were intentional about ensuring representation for Black students in science classes. They did this through projects, biographies of Black scientists, and incorporating Black culture, experiences, and histories in their lessons (Dei, 1996; Gay, 2002). These teachers used a variety of approaches and ideas to ensure Black students were provided with sufficient science capital to succeed.

The participants reportedly built strong and rewarding relationships with Black students and their caregivers by being persistent, and by refusing to assume negative motives behind caregivers' seeming lack of support. Their success with students points to the need for non-Black teachers to invest time and effort into creating trusting relationships with the Black community, including Black colleagues. Malinen and Roberts-Jeffers (2021) and Sylvestre (2021) highlight the fact that deficit perceptions held

by White teachers of Black students are still a problem in Canada. The systemic racism found to be pervasive in school boards of Ontario (James & Turner, 2017) provides evidence that much work needs to be done in building bridges between the education system and the Black community. It is the right of every child to feel safe in educational spaces, yet it is obvious that our Black students do not always feel safe in science classrooms; the onus is on educators to address and repair some of the historical damages. In addition, our participants cautioned that teachers need to be authentic in their relationship building with students due to the conspicuous ability of Black students to home in on performative acts of support and general inauthenticity displayed by some teachers towards them. This might be due to their heightened spirituality, one of nine dimensions of African Americans which can be traced to West African roots (Carter et al., 2008).

Our findings bring a question of who should teach Black children, and although some studies (Coffey & Farinde-Wu 2016, Hayes et al., 2014; James-Gallaway & Harris, 2021) suggest that Black students thrive when taught by Black teachers, Gay (2000, p. 205) cautions against presuming that "membership in a [racial] group is necessary or sufficient to enable teachers to do culturally competent pedagogy". Our findings from the stories of these three racially and culturally diverse teachers suggest that teachers of any race can embrace CRT and CRP, thus challenging the notions of hegemony in another form. We also ask teacher educator programmes to include a broader perspective of multiple cultures and to work with students' prior knowledge to foster positive experiences in science classrooms. Similarly, Milner (2007) cautions that teacher selection should not simply be because of belonging to the same groups, but rather, those teachers who are culturally aware. We assert that it is important to learn strategies and practices utilized by successful teachers of Black students, regardless of race, so that we might understand the needs and challenges experienced by Black students from a wider perspective. This can be done through the personal stories of successful teachers who can describe their culturally responsive teaching praxis. This, according to Gay (2018), provides "the most powerful evidence of teacher effectiveness" (p. xxvi), as the stories do not present prototypes but living examples of the exemplification of principles and practices of culturally responsive pedagogies.

Conclusion and Implications

From our study, we conclude that CRP and CRT are being successfully implemented by science teachers in their classes by way of building strong, meaningful relationships with Black students, so they feel included and safe. Effective teachers intentionally pursue relationships with Black students and their caregivers, and understand that it takes time, persistence, and effort due to historical challenges. Additionally, they implement CRP and CRT by integrating characteristics which are strong in Black culture, such as group work, bodily movement, and hands-on activities in their science lessons, to motivate and engage students. They provide science capital in the form of Black role models in science, contributions of Black scientists, and examples of Black scientific development, and display high expectations of students to affirm their identities. We also learned that successful science teachers of Black students have personal reasons for their commitment which may be due to shared ethnicity, commitment to being an effective teacher of all students, or a personal motivation to be an ally in dismantling anti-Black racism. Our participant teachers exemplified culturally relevant pedagogies and culturally responsive teaching (Parhar & Sensoy, 2011; Paris & Alim, 2017) harmonizing with science content knowledge in their respective classrooms.

While the study is predicated on the interviews of only three teachers, we found sufficient substance in the transcripts to align with the work of other teachers who use CRP and CRT in their subject areas with a focus on Black students. Further, we trust the recommendations of our referees to purposefully recruit these three participants, as they themselves were expert educators. Though having a larger sample size

would no doubt yield more information, this may not have generated more themes or brought additional insights. We feel this study helps to fill the gap in the literature and stimulate conversation around the conspicuous absence of Canadian-educated Black students in senior science classes and postsecondary science programmes in Ontario and throughout Canada.

These findings have several implications for educational practitioners such as teachers, curriculum developers, teacher educators, and policymakers in Ontario. They point to the urgent need to dismantle anti-Black racism within educational spaces, to remove deficit perceptions of Black students, and to address unconscious bias among educators. They show that science teachers can be successful with Black students when their perceptions of them are positive, and they are committed to Black student success and well-being (Dodo Seriki, 2018). The success of the participants reminds us that if we desire to teach all students effectively, teachers need to be able to make informed decisions based on school contexts (Krugly-Smolska, 2013) and be contextually prepared with the tools to facilitate student success (Aronson & Laughter, 2016).

Additionally, the study highlights the need for more Afrocentric curriculum–related input and support, so Black students can see themselves reflected in their education in ways which are empowering (Dei, 1996; Ladson-Billings, 2009; Wane, 2011). Finally, the study implies that more work needs to be done in Ontario to prepare teachers—through teachers' college and professional development activities (Gay & Howard, 2000; McCready et al., 2011; Mujawamariya et al., 2014; Patton, 2011; West-Burns et al., 2013)—to consider how the science curriculum is presented, and to understand racialization and discrimination and the ways in which this affects teaching and learning outcomes for Black students.

Recommendations that follow from the study are that science teachers employ a critical lens to the curriculum and their own pedagogies, so that they can become aware and respond to the diverse needs of learners in their classrooms (Aikenhead & Elliot, 2010; Dodo Seriki, 2018; Ladson-Billings, 1995a, b). Further, debates on science education abound with calls to increase access to all groups. It must be of concern to everyone if certain groups feel excluded from science in school and as a career, whether Black, Indigenous, female, or of another minority. Finally, teacher education programmes must foster tough conversations about inclusion and exclusion in science education, and develop effective models for CRP and CRT.

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Declarations

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