

Article

Building Science Teacher Leaders for Indigenous Schools: Lessons from a Science Professional Development Workshop in Nepal

Bhaskar Upadhyay ^{1,*}  and Saule Sadykova ²

¹ Department of Organizational Leadership, Policy, and Development, University of Minnesota, Minneapolis, MN 55455, USA

² Foreign Philology and Translation Studies Department, Faculty of Foreign Languages, K. Zhubanov Aktobe Regional University, Aktobe 030000, Kazakhstan; ssadykova@zhubanov.edu.kz

* Correspondence: bhaskar@umn.edu

Abstract: This is a case study of a science professional development workshop in Nepal with 17 teacher participants from four public schools. These schools mainly served Indigenous students in elementary, middle, and high school (Grades 9 and 10). The workshop focused on educating and building science teacher leaders for culturally relevant teaching and antiracist pedagogy by valuing and integrating Indigenous leadership practices and local knowledge. The teachers participated in a 2-day workshop co-organized by the local district education office and the local high school and led by the high school principal and a U.S.-based university faculty. Data were collected during and after the workshop through field notes, audio/video recordings of some sections of the workshop, and focus group interviews with a select group of participating teachers. The analysis of the data showed (a) struggles and opportunities to prioritize Indigenous science knowledge and Tharu sociocultural connections, (b) teachers seeking affirmation from principals to be science teacher leaders modeled on Indigenous leadership values, and (c) greater willingness for culturally relevant pedagogy among female and Indigenous teachers. The hope is that this paper will contribute to the value of a science teacher leadership professional development program (PD) in building awareness among science teachers about the value of culturally appropriate antiracist pedagogy in science teacher leaders. In addition, the PD also shows that science teacher leaders in Indigenous schools would benefit from the Indigenous relational model of leadership in leading their peers and students in antiracist and culturally relevant science teaching and learning. Finally, the study seems to indicate that a successful science teacher leader always incorporates local Indigenous community values, knowledge, and practices.

Keywords: science teacher leader; antiracist; indigenous; science education; culturally relevant



Citation: Upadhyay, B.; Sadykova, S. Building Science Teacher Leaders for Indigenous Schools: Lessons from a Science Professional Development Workshop in Nepal. *Educ. Sci.* **2024**, *14*, 964. <https://doi.org/10.3390/educsci14090964>

Academic Editors: Dorothe Kienhues and Klaus Zierer

Received: 6 July 2024

Revised: 9 August 2024

Accepted: 21 August 2024

Published: 2 September 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

In Nepal, schools, teachers, students, and parents traditionally view school science teachers as leaders because science is prestigious in the community and among teachers. Similarly, anyone with a degree in science is considered intelligent, hardworking, and a potential natural leader. In Nepal, schools highly value a science teacher leader who teaches to prioritize passing on the state, regional, and national tests [1]. Another vital teacher leadership quality valued in Nepal, specifically in Indigenous communities, is the relational quality [2]. For example, when the first author was growing up, he would add *didi* (“older sister”) after a female teacher’s first name and *guru* (“teacher”) after a male teacher’s first name. Thus, going to school and learning was about building relationships from an early age because Nepalis and Tharu Indigenous communities believe that learning built on relationships is enduring and socioculturally meaningful [3]. Despite the focus of many science teachers and school leaders on external regional and national exams, relational

connections in learning are the foundation of Indigenous communities. However, in the current environment of test-based accountability culture borrowed from the Western style of measuring learning [4], teaching science in Nepal has drifted away from a relational model to a managerial model with lesser connections to the larger racial, sociocultural, and historical discrimination faced by marginalized groups, specifically Indigenous students [5]. Yates et al. [6] have argued that the culture of audit-based education and accountability promoted through international assessment systems such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) have reduced the value of locally designed and indigenized curriculum and leadership frameworks. Therefore, there is a need for schoolteachers, specifically science teachers, in schools serving primarily Indigenous students in Nepal to take the role of science teacher leaders.

Furthermore, these teacher leaders help build culturally relevant values and practices in science teaching and learning through relational leadership. Hence, they could potentially aid in improving science teaching and learning in these schools. Additionally, Blakeney [7], Lawrence and Tatum [8], Sleeter [9], and other scholars have constantly demanded that teachers need professional development in antiracist and culturally relevant pedagogy for an inclusive and culturally supportive classroom teaching in schools of majority students from underrepresented groups. Similarly, Fortney et al. [10], Upadhyay et al. [3], Ballard et al. [11], Jeong et al. [12], and other scholars of science education have advocated for building science teachers' antiracist and culturally relevant pedagogical skills, thinking, and practices both in teacher education programs and professional development workshops and initiatives. Thus, this paper seeks to show the value of professional development (PD) that helped to build science teacher leadership capacity among teachers who taught in a school in Nepal that mainly serves Indigenous students.

The authors are not surprised that Spillane and Hopkins [13] found that the content area greatly influences teacher leadership because of the greater value placed on content-specific contextual expertise. Similarly, a qualitative study of school principals and teachers also showed that when school leaders are not content experts, the content teachers generally devalue the feedback on content-specific instructional practices provided by the school leaders [14]. Therefore, the focus of science teacher leaders on content mastery is common. However, a disconnect between students' life experiences and science content leaves many marginalized students disengaged and disinterested in science, with poor performance on science achievement measures [15–17]. For Indigenous students, the disconnect lies in cultural differences between science and Indigenous cultures [18–21], ways of knowing (epistemology) [22–26], interconnections between knowledge and life experiences and values [27], and history of racial discrimination in schooling and schools [20,21,28]. Hence, Indigenous epistemologies, ontologies, and axiology differ from science classroom epistemologies, ontologies, and axiology [29–31]. Thus, schools need science teachers and teacher leaders who can bridge these differences [32] and teach pedagogically antiracist and culturally relevant science. So we believe science teachers and science teacher leaders could benefit from professional development (PD) to help build Indigenous leadership capacity to infuse Indigenous social, cultural, epistemological, and historical issues into science teaching and learning.

Additionally, science teacher leaders from Indigenous and non-Indigenous communities could further help bridge gaps between Indigenous knowledge, ways of knowing, and culture and Western science practices that school science promotes. We conceptualize cultural relevancy and sociocultural and historical connections in science teaching and learning as the basic foundation of antiracist pedagogy. Therefore, building science teacher leaders on the above notion of antiracist pedagogy with relational leadership at the core could be one way to connect science to Indigenous culture, history, sociocultural discrimination, ways of knowing, and the personal experiences of Indigenous students. Thus, in this paper, we explore the experiences of Indigenous and non-Indigenous teachers in a two-day-long PD that focused on building science teachers' leadership capacity. Specifically,

we seek to understand how the teachers see their move towards antiracist pedagogy as a part of their science teacher leadership, what potential challenges science teachers see in leading an antiracist science pedagogy, and overall, how they see themselves as science teacher leaders.

Three questions guided the study:

1. What pedagogical shifts did the PD help science teachers reflect on to become science teacher leaders for antiracist pedagogy in their schools? Why?
2. What challenges do science teachers see in leading antiracist pedagogy in their schools? Why?
3. How do they see themselves as science teacher leaders?

2. Research Framework and Literature Review

To answer these questions, we used a theoretical framework based on the ideas of antiracist pedagogy [7,8,33], culturally relevant pedagogy [34,35], teacher leadership [36], and Indigenous leadership [37]. These frameworks not only support us in understanding why science teacher leadership experiences in Indigenous student-majority schools are urgently needed but also help us in the literature review and the collection and analysis of data from the PD workshop. We use qualitative case study methodology and methods [38] to collect data and qualitative analytical processes to analyze the data [39]. We bounded our case by the 2-day-long PD and teachers' experiences in the PD and their reflections on teaching that they shared during the PD. We present our themes as findings, a standard method of presenting results and findings in a qualitative study, followed by discussions and implications of the study.

3. Why Antiracist Pedagogy?

For the purposes of this paper, we conceptualized antiracist pedagogy [7,33,40] to mean teaching science in a way that exposes historically and culturally embedded racial discrimination in the school science curriculum, content, and practices, as well as supports students to understand discriminatory obstacles that allow for unequal distribution of resources [41]. Considerable research has shown that cultural relevancy [34,35], cultural responsiveness [42], cultural sustainability [43], and cultural revitalizing [44] improve teachers' pedagogical effectiveness with marginalized students and provide culturally meaningful [21–23,45,46] and antiracist learning experiences [35,42,47]. However, there is a considerable concern among science education and Indigenous scholars that many teachers from dominant groups utilize cultural relevancy in their science teaching superficially—focusing on vocabulary, traditional food, and clothes but failing to engage in critically examining the nature of knowledge and sociocultural and sociohistorical discriminatory issues [6,23,48–51].

We agree with Galloway et al. [48] that antiracist pedagogy explicitly asserts the prejudices, discrimination, and marginalization experienced by minoritized groups based on their “race, gender, language” (p. 486), history, culture, and other forms of locally experienced biases in science teaching and learning [46]. Antiracist pedagogy does not dilute the value of culturally relevant pedagogy but enhances it by directly confronting race and racism in science teaching, supporting students to examine how the science they learn and engage in has excluded their local knowledge, culture, and ideas. Furthermore, antiracist pedagogy explicitly questions and challenges standard classroom science and extends it to explore historical and current sociocultural, sociohistorical, and sociopolitical issues in the community.

In the case of the Tharu Indigenous community in Nepal, racism manifests in science classrooms by promoting the dominant group's values and ideas in science curriculum, history, and classroom pedagogy [1,52]. For example, in the science curriculum and Grades 9 and 10 textbooks, sickle cell disease is mentioned and taught as a scientific fact. However, it is not discussed in a way that dismantles the popular myth in dominant Nepali media and groups that “sickle cell is a Tharu disease” ([3], p. 1131). This myth has become a stereotype

because sickle cell is predominantly seen among the Tharu Indigenous groups in Nepal [53]. Similarly, when science teachers engaged students in science and environment science textbooks and curriculum, Tharu knowledge about irrigation systems (described later in the section on *kulwak aguwa*—leader of the irrigation canal system) is hardly connected as legitimate knowledge when teaching environment and food sustainability subjects. As standard science curricula and textbooks have preference over Indigenous knowledge, many science teachers in Indigenous schools find connecting Indigenous knowledge challenging as a part of antiracist pedagogy that questions the power of established Western science [29,54] and engages students in local social and environmental issues that value Indigenous science knowledge, culture, and ways of knowing [29,55]. Therefore, an antiracist pedagogy teacher would name and point out the places in science textbooks and curriculum that negatively stereotype Indigenous and other underrepresented groups to draw students into critical discourses of racial and other forms of discrimination [56–58] that Tharu communities have experienced over generations.

Therefore, in this paper, we consciously argue for including Indigenous culture, knowledge, and practices as integral parts of an antiracist pedagogy. In the context of antiracist pedagogy, we consider cultural relevancy an essential part; without cultural and historical relevancy, antiracist pedagogy fails to legitimize Indigenous knowledge in the science teaching and learning experiences of Indigenous students. Thus, antiracist pedagogy helped us understand science teacher leadership and the experiences of science teachers during the PD as antiracist pedagogues.

4. Teacher Leadership in Nepali Context

Before we present a brief literature review related to teacher leadership in Nepal, a brief description of school hierarchy might help readers understand how school leadership works in Nepal. In all Nepali public schools, the principal or headmaster is appointed by the local district education department [59]. Therefore, a principal in a school might be a senior teacher from that school, or that person can be sent directly from another school. Since the principal has the backing of the district education department, the principal wields tremendous power and authority over all aspects of the school, specifically budgetary and curricular matters. On the other hand, the principal generally decides who leads each of the content areas and other school programs and activities. Therefore, becoming a content area leader depends on the principal's decision and support. Furthermore, without the principal's support, a science teacher leader can face numerous challenges when implementing antiracist and culturally relevant pedagogy. Thus, inviting and engaging school principals in a professional development workshop on antiracist and culturally relevant pedagogy is essential and desirable [60]. So, in this study, we invited several principals, and three of them attended the PD because science teacher leadership needed the principal's understanding of and buy-in to antiracist and culturally relevant pedagogy.

Success in school and life comes from mastering critical reflection and thinking, which allows students to connect science content and practices with the local sociocultural values, beliefs, and systemic discrimination [61]. In Nepal, most teachers see little value in teaching science for social and personal transformation [62] because of the test-centered accountability system [63]. In schools with marginalized students, the dissonance between science content and community sociocultural practices and histories of discrimination gets magnified. Therefore, antiracist science teacher leaders can bring cultural relevancy to their pedagogy through local sociocultural and historical practices for a connected science learning environment. Science teacher leaders can harness their deep commitment to science teaching for social change and empowerment. They can also engage students and other teachers in critical reflections on local racial and systematic discrimination [59].

Science teacher leaders can engage students by drawing from antiracist pedagogy in everyday instruction and engagement in promoting change [64]. Further, science teachers can influence colleagues through collaboration, mentoring, and sharing the best ideas transferable to other subjects [65,66] and informed by Indigenous knowledge and prac-

tices [50]. Finally, to improve engagement and future science-related career choices by marginalized groups, science teacher leaders cannot ignore cultural diversity, social justice, history, and equity issues in school and in students' lives. Therefore, PD supported by the local education office, schools, Indigenous Tharu teachers, and principals was essential to educate science teachers on the benefits, challenges, and value of culturally appropriate antiracist pedagogy. The PD would help build science teacher leaders' capacity to improve their own and their peers' pedagogy and curriculum into antiracist pedagogy that values Tharu leadership practices, culture, knowledge, and history.

One avenue to educate, formulate, and encourage science teachers to take leadership roles is to provide focused PD for culturally appropriate antiracist pedagogy relevant to science teaching and learning in a predominantly Indigenous school. Transforming teacher-centered content-focused pedagogy into antiracist pedagogy requires educating science teachers on the benefits of engaging content learning with discriminatory sociocultural issues and valuing Indigenous knowledge and cultures in science.

We first want to present the Tharu leadership model to demonstrate the culturally appropriate leadership the school needs and the community values. The example below illustrates a Tharu leadership model focusing on processes, skills, practices, cultural values, and Indigenous knowledge.

5. Tharu Leadership: Kulwak Aguwa (Irrigation System Leader)

This section briefly describes the overall leadership selection process in the Tharu community where this study took place. Then, we present the leadership characteristics (skills and values) of a *kulwak aguwa*, an irrigation system leader. Only a Tharu man can be *kulwak aguwa* because he has generations of knowledge, skills, and values for the well-being of the community at large. The leaders in all Indigenous communities focus on how the holistic well-being of a community can be attained and preserved [67], and they continuously strive to find leaders who have those qualities [67]. Thus, Tharu leaders are similar to any other Indigenous community when selecting a leader with serious responsibilities.

In the Tharu language, *kulwa* means "a human-constructed small waterway primarily used for irrigation and other purposes", and *aguwa* means "leader". The Tharu community in Southwestern Nepal has its own leadership tradition. The leadership structure is based on a governance model [68] where the community selects the most skilled, knowledgeable, and fair-minded elder (who could be a Tharu person as young as 30) for critical leadership positions. In the Tharu community, the four most important leadership positions need the most knowledgeable and skilled leaders: *badghad* (leader of the community as a whole, village chief), *kulwak aguwa* (leader of the entire irrigation system), *chowkidar* (communication leader, village watchman and messenger), and *deshbandhya guruwa* (head faith healer of the village and the region taking care of medical and shaman work of a region). Except for the *deshbandhya guruwa*, the village community elects leaders through a one-vote-per-household system. However, in most cases, the leadership positions are filled with broad consensus among the elders. Critical needs are settled during the community meeting before the election process begins for each leadership position.

Furthermore, each leader selects an assistant based on prior experiences, knowledge of the task, accountability to the community, Tharu community values, and well-being. Before choosing the leaders, the community, led by a village elder present in the gathering, asks for guidance from the ancestors, spirits, and gods. Specifically, prayers are chanted for the safety, life, and wise decisions of the *kulwak aguwa*. Prayers for goodwill and safety are because *kulwak aguwa* leads people into situations where many life-and-death decisions must be made. Other researchers have also argued that in Indigenous communities, these leadership qualities and governance models are central to the community well-being, the preservation of Indigenous knowledge, and the building of stronger communal relationships for the greater good [69,70].

6. Cultural Relevancy and Indigenous Science Knowledge

Scholars of science education and specifically scholars of Indigenous science education have been advocating for and taking actions to make science culturally relevant, supporting other ways of knowing, making sense of Western science based on local knowledge and practices, and leveraging science for social change and justice [18,22,71–73]. In all of these studies, one feature has been consistent: Indigenous knowledge and Indigenous science knowledge originate from acute and dynamic observations of the local environment, where humans are part of it. Ontology and epistemology are always about seeking relational knowledge [50,74] and meaning that sustains the balance between the community and the environment. In the first author's work with the Indigenous Tharu community in Nepal, the primary feature of knowledge generation is constantly observing the place in relation to the land, plants, animals, and the Tharu people. In the *kulwak aguwa* example, the knowledge about the dam building was based on the observations that valued the relationship between the Tharu communities, the behavior of the Karnali River, the soil, vegetation, and the care for the people under his leadership. Knowledge of the workings of the irrigation system relied on respecting nature. The Tharu epistemology is guided by the relationship built on the mutual understanding of the Tharu community and the reverence for the Karnali River and the local place. Therefore, learning and generating knowledge in the Indigenous community rely on building relationships with the place and its inhabitants rather than individualistic profiteering without a sense of reciprocity. In its pedagogy, epistemology, and ontology, Indigenous science education values relational well-being, a nonnegotiable cultural marker.

Another feature of Indigenous knowledge that differs from modern Western science is the acceptance that knowledge is local and could have multiple meanings and processes depending on its usefulness [73,75,76]. Valuing Indigenous knowledge allows teachers and students in science classrooms to interrogate both the processes of science and the value of that knowledge for the local community. Students look for personal meaning in anything they learn, allowing them to connect science to their sociocultural experiences, local practices, and local environments [45,77,78]. Therefore, all science teacher leaders in Indigenous schools must recognize, actively practice, and value Indigenous ways of knowing, culture, relationships, and local places.

7. Examining Science Teacher Leadership

In this section, we present a broad overview of science teacher leadership in current publications, followed by the Indigenous leadership model to describe the nature of antiracist pedagogy that we seek in the PD workshop. A teacher leader can immensely influence classroom practices and the curriculum, impacting colleagues and the school in multiple ways [65,66,79]. As teacher leaders are asked to play multiple roles, the literature on teacher leadership has yet to have an agreed-upon definition of a teacher leader. Here, we present several definitions of teacher leadership (based on a Western framework) that are both complementary and contrasting, showing a need for a definition that recognizes the value of cultural relevancy in teacher leadership, specifically in science teacher leaders who intend to serve Indigenous schools or Indigenous-majority schools.

Wasley [80] defined a teacher leader as having “the ability to encourage colleagues to change, to do things they would not ordinarily consider without the influence of the leader” (p. 23). Katzen-Meyer and Moller [81] suggested that teacher leaders “lead within and beyond the classroom, identify with and contribute to a community of teacher learners and leaders, and influence others towards improved educational practice” (p. 17). Boles and Troen [82] defined teacher leaders as showing “collective leadership in which teachers develop expertise by working collaboratively” (p. 11). Others have defined a teacher leader as a peer collaborator, coach, and mentor [65,66]. All definitions of teacher leadership that we found [64–66,79–81,83] did not explicitly mention equity and social justice. Scholars have advocated for equity and social justice as more of an aspirational goal than an essential part of being a teacher leader in increasingly diverse schools. As the diversity of students

has increased in many communities and a desire to bring more Indigenous students into the STEM fields has taken an urgency, scholarship in school leadership increasingly focuses on the value of cultural relevancy, equity, and race in effective, inclusive, and antiracist leadership [36,84–86].

Teacher leadership has been the focus of study in education for a while, but science teacher leadership has received less attention [83,87–89]. However, in the United States, the National Science Education Leadership Association has advocated for science teacher leaders to bring positive and culturally relevant science teaching pedagogies through local, state, and national policies [89]. Furthermore, science teacher leaders guide innovative and culturally relevant science teaching and can influence local and national policies and practices [89] and teachers of other content areas [88].

A study of academically successful urban elementary schools showed that students' achievement in fifth-grade science was correlated to activities that science teacher leaders promoted [83]. Furthermore, the science teacher leaders enjoyed a uniquely supportive school culture that provided the teachers with curricular and scheduling freedom, many science-content PD opportunities, parental support, and easy access to science resources. Wenner did not explore cultural diversity and equity issues.

A common belief among science teachers is that science teacher leaders must have knowledge and skills in content areas rather than leadership qualities such as mentoring, professional organization participation, community outreach, and in-school PD for peers [90]. A study of high school science teachers' perceptions of teacher leader identity formation showed that teachers tend to lead essential school and out-of-school activities but consider these engagements irrelevant to being a science teacher leader [90]. Hanuscin et al. [90] argued that to build science teacher leaders, a professional development program needs to bring together identity issues, science practices, and views about leadership as core aspects of leadership preparation. However, their study did not focus on equity, cultural diversity, and social justice issues as essential aspects needed for science teacher leaders to succeed in a school of underrepresented students.

Individual science teachers can be nurtured into becoming science teacher leaders through engaged and directed PD [91]. Their study of three experienced middle school science teachers showed that leadership skills such as positive interdependence between science teachers and scientists, opportunities to lead in-school and out-of-school spaces, and prospects for leading in challenging tasks helped build the confidence to be science teacher leaders. Although modeled on the social aspect of engagement, the study did not explore cultural relevancy as an essential aspect of science teacher leaders.

Luft et al. [87] found that not all science teachers want to be teacher leaders. The study highlighted the difficulty characterizing science teacher leaders' roles in building leadership capacity. Luft et al. indicated that collaboration, an "individualized leadership plan" (p. 8), and the understanding of new policy changes such as the Next Generation Science Standards [92] are essential ways through which to build science teacher leader skills. Hofstein et al. [93] also noted the importance of group cohesion and collaboration as science teacher leaders. The limited empirical studies in the context of science teacher leaders have lacked a focus on culture, equity, racism, and social justice issues as a part of leadership development. The science teacher leader research synthesized above focused on diversity and sociocultural aspects of leadership as ancillary rather than central.

Additionally, more work needs to be conducted on Indigenous science teacher leadership. Most research has focused on science teacher leaders from dominant groups using a Western leadership model as a universalist perspective. This study intends to broaden discussions within science teacher education communities to explore Indigenous leadership models to make science teacher leadership more culturally and racially inclusive. This study focuses on how a PD workshop helped teachers consider Indigenous values and culture for an antiracist and culturally relevant pedagogy in a science teacher leadership model.

8. Indigenous Leadership Model: Inclusive, Communal, and Relational

The leadership literature reviewed above did not recognize non-Western practices of leadership, specifically the Indigenous leadership framework. In an Indigenous school, science teacher leaders must value and promote an Indigenous leadership culture that supports better learning for Indigenous students. Most leadership frameworks utilized in leadership development workshops and educational institutions are based on a Western managerial framework where individual assertiveness, task orientation, and decisiveness are valued over relationships [94–97]. In the Western models, a single person is responsible for knowing and leading disparate fields despite not having expertise or knowledge in many areas. From the Western leadership model, the leader exhibits power by “transmitting intentions” ([37], p.6) and influencing outcomes that the leader wants with less attention to the health of the larger community [98]. In the Western leadership model, the leader may not be a community member but is tasked to lead people and organizations without much connection to the community [37,99]. Therefore, the leader brings values, attitudes, beliefs, and cultures without historical, social, cultural, or linguistic connections to the Indigenous community. We have no illusions that leadership models are not the same in every Western or First World country. They differ in many respects, but most have similar individualistic ideas of leaders as “go-getters” [100]. The gulf between a Western-framed leader and an Indigenous-framed leader is so vast that an Indigenous community hardly benefits from the initiatives of the leader, thus jeopardizing and pushing back Indigenous people’s well-being. To mitigate the detrimental effects of the Western leadership framework, we need to incorporate the Indigenous leadership framework in science teacher leader PD to be better stewards of Indigenous students’ science learning and engagement.

Contrary to the Western leadership model, Indigenous leadership is founded on a relational view of leading [94,97]. Indigenous communities do not follow a universally generalizable Western leadership framework because each Indigenous tribe or community is either sovereign or has different sociocultural and sociohistorical values, thus differing in the nature of leadership. In a study of community management and administration among Indigenous groups in Australia, Stewart and Warn [37] found that the Indigenous leaders valued relationships based on the cultural values and identities of an Indigenous group rather than a task-oriented distal framework. Similarly, Coyhis [101], Wheatley [102], Wilke and Speer [103], and many others have stated that Indigenous people view leadership as valuing cultural beliefs and see a top-down model of leadership as less aligned with Indigenous ways. In Assiniboine (also known as Hohe or Nakota) Indigenous groups in Canada, leadership is based on community well-being [104]. Shanley and Kenneth [104] gave an example of an Assiniboine leader hunting for food for someone in the community. The food is handed over to the community member, who later dispenses food to the leader if the person chooses to do so. Like this leadership model, Tharus in Southwestern Nepal shares animal protein with all family members equally, irrespective of age or status. Thus, an Indigenous leader for the community or the household is inclusive and values the health of the entire group rather than just their own successes.

Indigenous leadership relies on skills and knowledge that benefit the community because Indigenous people believe in interconnectedness among humans, places, plants, animals, and their spiritual beliefs and values [104,105]. Thus, culturally guided leadership is an essential aspect of Indigenous leadership because the Indigenous community believes in holistic thinking in a leader. For example, Maori leadership is highly culturally contextualized [106], and the responsibility of the Maori leader is to preserve and sustain the Maori way of seeing the world.

The brief review of Indigenous leadership in educational and other contexts shows that the leadership framework is guided by a holistic and relational view of the community, which values the well-being of the community rather than expediency. Indigenous leadership values contradict the Western top-down framework, which valorizes the individual leader rather than the community at large. Thus, to change the existing top-down and individualistic leadership model in predominantly Indigenous schools, culturally relevant

antiracist pedagogy could provide the groundwork for developing science teacher leaders based on the Indigenous leadership model.

Antiracist pedagogy in Indigenous schools builds on the idea that science teacher leaders need to engage students to question, reflect on, and disrupt systems of oppression to provide opportunities and voice for personal and social change through science [7]. We agree with [33]: “Antiracist pedagogy is not simply incorporating racial content into courses, curriculum, and discipline. It is also about how one teaches, even in courses [and school activities] where race is not the subject matter” (p. 540).

Generally, science teachers’ focus on science content hinders their ability to connect content to more significant sociocultural and sociopolitical issues [55,107,108]. Science teachers and their students should find space to ask unsettling questions that link science to larger sociocultural and historical issues of the Indigenous community [109]. We believe that science teacher leaders and principals are critical to the success of antiracist pedagogy that explicitly works to support Indigenous leadership values. Teacher leaders and principals can take action to eliminate structural inequalities in classrooms and school systems [36]. Students often experience a cultural collision through curriculum and pedagogy that devalues their individual or collective cultures [110]. Therefore, antiracist pedagogy is culturally relevant and responsive to the local cultures and histories of the students and the Indigenous community.

In this paper, we present findings from a 2-day science PD workshop focused on antiracist pedagogy to help teachers consider science teacher leadership that supports science learning and engagement among Indigenous students by infusing sociocultural and historical discrimination and Indigenous leadership values into science teaching and learning. The PD aims to build the capacities of science teachers to become science teacher leaders so they can work toward changing the biased system to benefit Indigenous students and teachers. This professional development (PD) workshop will at least build awareness among the teachers that science teacher leadership will be successful in Indigenous student-serving schools when Indigenous culture, issues, and knowledge are connected to science. Furthermore, the PD will add greater realization and a sense of importance that antiracist and culturally relevant pedagogy plays an essential role in successful science teacher leadership in a school that serves Indigenous students.

9. Methods

We used a case study design and methodology to answer these questions because it allowed us to capture in-depth, contextual, and real-world [38,111,112] experiences of the teachers during the professional development (PD) workshop and provided teachers with the opportunity to reflect and connect their teaching experiences with the learning from the PD. According to Merriam, a case is “a thing, a single entity, a unit around which there are boundaries” (p. 27), and it can be an individual, a classroom, a program like the PD, a group, a specific policy, and many other entities. The 2-day long PD bounded our case study design, recordings of the PD, post-PD interviews, and teachers’ reflections about their teaching in relation to what they learned during the PD. We specifically used Merriam’s idea of the case study [38] because it allowed us to explore how and why teachers’ actions, reflections, thinking, participation in the PD, reflections on/in PD and their teaching choices, connections to antiracist pedagogy, and cultural relevance in science teaching. The antiracist science teacher workshop gave insights into how and why teachers were supportive of or reluctant about antiracist pedagogy (see Creswell [113]). Therefore, we believe the case study allowed us to understand teachers’ experiences in the PD better, their intentions to be antiracist science teacher leaders, and how they saw themselves as science teacher leaders in their schools. Finally, we recognize that the findings of this study are not generalizable because of the sample size, purposive sampling method, and the context of the study.

10. School and Participant Selection

The school where the PD was conducted is in the Southwestern part of Nepal. The first author has collaborated with the school to build science and non-science teachers' pedagogical capacities for the last ten years. This is the fifth workshop the first author conducted in the school. Therefore, the researcher has a trusting relationship with the teachers, students, and the community.

The first author selected five participants (Bikash, Maya, Bimal, Mangal, and Mukhiya) for the post-workshop interviews. The names of the participants are pseudonyms to mask their identities.

The participants were selected purposefully from those who participated in the workshop because this allowed us to capture in-depth and nuanced experiences relevant to answering the questions [38,39,112]. Furthermore, we selected the participants representing geographic variations, Indigenous and non-Indigenous communities, and the grade level they taught (elementary, middle, and high school). These variations allowed us to capture differences in perspectives and experiences as well as improve the trustworthiness and validity of the findings [39].

11. Methods of Data Collection

We followed Merriam's [38] suggestion that a case study must collect data from numerous sources to ensure that the findings are trustworthy and valid. We collected data utilizing several methods: video recordings of the PD, post-workshop participant interviews, field notes during the workshop, retro-reflective notes of the first author, and participant-generated artifacts.

PD Recording: We recorded videos of the 2-day PD to document workshop participants' interactions in group activities, discussions, questions and answers, and responses of the participants and the PD facilitators (first author and a principal). Furthermore, the PD recordings helped us understand the participants' voices and later became a basis for several interview questions and reflections. For example, we used "irrigation system", "malaria", "sustainable farming", and "female issues" as critical activities to engage teachers in the PD in exploring antiracist and culturally relevant pedagogy. Table 1 shows some of the ideas of the participants and the activities.

Field Notes: The researcher (first author) kept observational and reflective field notes in which many one-to-one and group conversations were documented. Some of the conversations that could not be captured in the PD video recordings were documented in the field notes, specifically, among those participants who were farther away from the video recording devices.

Retro-Reflective Field Notes: In the retro-reflective field notes [114], the first author documented not only overall impressions of the PD and teacher interactions but also added reflective perspectives on goal attainment and the memo on how the teacher participants took up the PD. Retro-reflective field notes also helped add details on individual and group interactions on questions about cultural relevancy, antiracist pedagogy, and Indigenous leadership in the context of science teaching and learning. The first author also used this to document his retro-reflective thinking, views, challenges, opportunities, and potential next steps about the workshop and individual teachers. The retro-reflective field notes also included potential clarifying questions and future directions for teacher PD focused on antiracist and culturally relevant pedagogy.

Post-PD Interviews: The first author conducted post-PD interviews with five participants (Bikash, Maya, Bimal, Mangal, and Mukhiya) and audio-recorded them. We later transcribed the interview for analysis. The goal of the interviews was to capture teachers' experiences in the PD, connections to their lived experiences as teachers, and how Indigenous leadership, culture, knowledge, history, and values connected with science teacher leadership. The first author held 2 h of focus group interviews right after the workshop. He conducted the interviews in Nepali, Tharu, or other local and regional languages in which the participants and the first author were fluent. Most teachers chose to

respond to interview questions bilingually or multilingually. Teachers mostly spoke Nepali and Indigenous Tharu languages, but some sometimes used short phrases in Maithili, Awadhi, Dailaykhi, and regional dialects and languages. The research questions, literature review, and authors' experiences and scholarship in this area informed the semi-structured interview questions. Some of the semi-structured interview questions were the following:

- What were the possible benefits of race [*jati*]-conscious pedagogy for you as a leader?
- How would students learn differently in your science class after this workshop?
- How do you see challenges of science teachers (leaders) in your school connecting culture and other social problems?
- As a science teacher leader, how are you thinking about changing from a teacher to a leader?

Table 1. Brief Summary of Teachers and their Thinking about science teacher leadership.

Teacher	Gender	Level	Ethnicity/Caste	Thinking about Science Teacher Leadership
Bikash	M	Elementary	Indigenous (Tharu) Comes from the local community that the school serves	Tharu language, knowing when and how to plant, malaria, kamaiya (bonded labor), principal support, not caring about Tharu students, engineering and doctor, role of Tharu community in school leadership
Maya	F	Elementary	Indigenous (Tharu) Comes from the local community that the school serves	Tharu language, malaria, bukrahi (female bonded labor), caring for family, doctor, failing science and math, Tharu teachers take lead role
Bimal	M	Middle	Maithali (Upper cast) Comes from Eastern Nepal, not from the Indigenous community	Like Maithali, Tharu language gets ignored, we cannot do that, we need more teachers, science and math teachers can be good leaders, and passing exams is essential
Mangal	M	Principal—High	Upper caste; comes from the local community that the school serves	Need Tharu teachers to take the lead role, principals have national test and Tharu culture to compete, and bonded labor puts pressure on family and the culture of working in the farm
Mukhiya	M	Principal—Middle	Upper caste; comes from the local community that the school serves	Not many Tharu teachers in secondary, bonded labor is detrimental, more support is needed for students from Tharu community, leadership is hard to bring to Thauras

12. Brief Description of Participant Teachers

There were 17 participants from four schools who participated in the PD. Of the 17, 3 were principals, and the rest (14) were schoolteachers. Furthermore, four high school teachers and one middle school principal were from outside the community. They were transferred to the Indigenous community schools by the district education office. All eight elementary teachers grew up in the Indigenous communities and were highly familiar with the Tharu culture, language, values, knowledge, and sociocultural issues. Of the three middle school teachers, two were from the Indigenous community (Sashi and Ruk). However, they did not belong to the Tharu Indigenous group, and the third teacher (Bimal) was from Southeastern Nepal and spoke the Maithili language, which is very different from the Tharu and Nepali languages. After arriving at his current school, Bimal had to learn the Tharu culture and language. The average teaching experience of elementary teachers was 6 years, that of middle school teachers was 8 years, and that of high school teachers was 12 years. Below, we briefly describe five teachers we interviewed to provide greater context and depth. The names of the participants are pseudonyms to mask their identities.

Bikash: He is a Tharu who has taught at the school for five years. He taught all subject areas but was more engaged in teaching science and mathematics. He was attending college for an undergraduate degree in general science education. His father was a bonded

laborer, so he was keen to take the lead in making science culturally relevant by drawing knowledge and social issues from the Tharu community.

Maya: She is a Tharu and the first in the family to be a schoolteacher. She had been teaching for four years in the school. She wanted to take the science teacher leadership role if an opportunity arose. She wanted to bring Tharu culture, specifically female-related Tharu issues, into her science teaching. Her mother used to be a bonded female worker. Maya was attending morning college classes run in the same school to obtain her grade 12 degree in general education. She taught science but mainly relied on the textbook and her Tharu knowledge to provide connections to students. She grew up in the same community where the school is located.

Bimal: He is a middle school science and mathematics teacher. He was transferred to this school two years ago but had been a teacher for eight years in another school. The Tharu community, culture, language, and values differed for him. He was learning the Tharu culture and receiving help from his colleagues. He has an undergraduate science and mathematics education degree.

Mangal: He is the high school principal who helped carry out this PD. He has an undergraduate biology degree and provided leadership in high school science. He had been in this school for more than 20 years. Even though he is not Indigenous, he knows the culture, language, knowledge, and elders extremely well. Tharus considered him one of the elders, a highly respectable acknowledgment of his commitment to their well-being.

Mukhiya: He is the middle school principal whom the district education office transferred from the nearby district, but with a very different culture than that of the Tharus. He is not a Tharu but has been learning the culture and language. He had been the principal of the nearby middle school for the last three years. He has a general education undergraduate degree.

13. Data Analysis

The overall framework of data analysis was based on thematic analysis because it allowed us to capture “meaning and identity to a recurrent experience and its variant manifestations. As such, a theme captures and unifies the nature or basis of the experience into a meaningful whole” [115] p. 362. The first author analyzed the data utilizing both the inductive and deductive methods informed by prior works on antiracist and culturally relevant pedagogy by Blakeney [7], Lawrence and Tatum [8], and Upadhyay et al. [3]. Some key ideas that informed the coding were based on the above scholars’ research. They included guiding ideas or codes such as the idea that science teacher leaders need to be aware of the demographic makeup of the class, cultural experiences of the students, cultural stereotypes about Indigenous or marginalized groups, mismatch between students’ culture and school science culture, negative view of Indigenous groups, ignoring Indigenous and local knowledge, failing to connect science to local issues, and lower status of Indigenous knowledge compared to science knowledge. According to Miles, Huberman, and Saldaña [39] and Merriam [38], in a qualitative interpretive case study, the analysis of the data is based on multiple readings and viewings of the interview transcripts, observations, fieldnotes of all kinds, video and audio recordings of the activities, and artifacts. They also recognize that qualitative data analysis is based on inductive and deductive processes because prior works of researchers inform the generation of codes and themes. Thus, when the data for this case study were analyzed, we took guidance from these scholars’ works [3,7,8] and based our analysis on Miles, Huberman, and Saldaña [39] and Merriam [38]. Based on their works, we initially came up with the following open codes: negative image of Indigenous people, poor learners, cultural mismatch -Indigenous culture and teachers, science and student culture disconnect, integration of community/student culture in curriculum, students’ experiences discounted in science teaching, and missing community issues as part of science.

We, in consultation with the Tharu elders and supported by the second author, generated 26 open codes informed by the above scholars’ work as well as inductively through multiple readings and viewings of the interviews followed by videos of the PD and the

retro-reflective field notes and field notes, respectively [38,39]. These initial open codes followed Merriam's inductive and deductive initial code generation guidelines. The initial codes included, for example, "Tharu culture", "relationship and holistic", "mismatch between Tharu culture and school teaching", "Tharus can't learn science", "science content not local culture", "fishing sustainably", "female teachers leading", "*kulwak aguwa*", "Tharu language", "female student challenges", "fishing net types", "kamaiya-bonded men", "kamalari-bonded women", "shaman-guruwa", "antiracist teaching challenges", "food sustainability", "principal support", "local science curriculum versus national", "national exam", "remuneration for leadership roles", "reluctance to identify as a science teacher leader", and "teacher leader challenges". We specifically focused on aligning initial codes generated from the analysis of the interviews with PD videos and the retro-reflective field notes. The alignment of codes allowed us to focus more on nuanced and in-depth analysis rather than quantity of codes.

Once the researchers agreed on the 26 open codes, we used axial coding [39] to generate nine larger codes such as "Social and cultural connections", "Science teacher or science leader", "Principals and barriers to remuneration", "Female teachers showing antiracist enthusiasm", "Being a teacher and science teacher leader", "Challenges of female science teacher leader", "Indigenous knowledge in science", "Elder leaders as guides to teachers", and "Tharu knowledge and language in teaching". These nine codes formed the basis for generating three themes (findings) that capture participating science teachers' thinking, dispositions, and challenges of becoming antiracist science teacher leaders and teachers (see Table 1). The three themes (findings) are (i) prioritizing Indigenous science content: social and cultural connections; (ii) seeking affirmation from principals on becoming a science teacher leader: managing a dual universe; and (iii) greater willingness to embrace antiracist pedagogy for female participation and Indigenous knowledge. We will present these in detail later in the findings section.

To increase trustworthiness, validity, and reliability, the authors utilized multiple methods of data collection that helped increase the triangulation of the data and analysis, included voices from multiple participants, and checked for the accuracy of the analysis by sharing results with the elders and participants. In addition, to improve the trustworthiness and validity of the codes, the authors came to an agreement on most of the codes, but when there were disagreements, they came to a consensus on those codes to either keep, modify, or discard them. We also shared a summary of the analysis with the Tharu teachers, Tharu elders, and a participating principal to ensure accurate representation and meaning-making. Table 1 below summarizes five teachers' thinking about science leadership and other demographic information. These teachers participated in the focus group interviews.

14. Professional Development (PD)

This 2-day PD focused on science teacher leader development by critically examining sociocultural and historical issues in science teaching and learning in the contexts of Nepali schools. The first author has been partnering and working with the school for the last ten years, providing several professional development workshops for the teachers, and this is one of them. Since effective science, technology, engineering, and mathematics (STEM) teaching entails drawing from local problems, we aligned the PD problems with the goals of understanding science and its relationships to other STEM fields and sociocultural issues. In the context of the schools in the district and the challenges Indigenous Tharu students face in science, a critical-theory-oriented and culturally relevant workshop can enhance pedagogy and help science teacher leaders provide change for their schools and peers. As the lead PD person (first author), he guided antiracist science teacher leadership PD based on the Tharu leadership framework. In the Tharu culture, a leader has a strong relational bond with the community and the environment, where knowledge is distributed among many people. For example, *kulwak aguwa* seeks help from experts in making ropes out of tree bark and tying wood logs together during dam building in the Karnali River.

Similarly, the PD drew heavily on the local Tharu knowledge about the land, plants, harvesting, irrigation, and cultural values. The workshop also utilized literature and newspaper clips on bonded labor practices in the area, sickle cell disease in Tharus, food (in)security, distrust between the national park and Tharus, the globalization of unhealthy food, gender discrimination, and the cost of climate change on the Tharu cultural practices and well-being. In the PD, we borrowed all the materials for antiracist pedagogy from the Tharu community (Tharu teachers and elders), Nepali print media, TV, and online sources. With the help of the first author, one of the schoolteachers translated some resource materials from English into Nepali during the PD. The PD was made more dialogic through uncomfortable discussions surrounding Indigenous science knowledge (we used *kulwak aguwa* as a critical example for the Indigenous science knowledge and leadership framework), school science curriculum, access, sociocultural and historical issues of the Tharus, assessments, and teacher resources. Tharu student voices, culture, history, leadership models, health and wellness, and systematic biases in schools were lively discussion topics.

15. Positionality of the Researchers

According to Merriam [38], researcher positionality is one of the ways to attain reliability in the findings. In this manuscript, the first author intimately knows the Tharu elders and the community because he grew up with other Tharu youths and adults. He speaks fluent Tharu and knows the evolution of the language over his lifetime. Even though he is not Indigenous, he has a strong and humble relationship with the land, water, the jungle, and the people of this community. He considers himself an outsider with the knowledge of many insider perspectives. Constructivist and critical epistemological paradigms guide his research and worldview. Therefore, he values Indigenous ways of knowing, culture, and history and views the PD on antiracist and culturally relevant pedagogy as a place for meaning-making by the participants through their lived personal and professional experiences.

The second author, a native scholar from Kazakhstan, brings a wealth of knowledge in foreign languages and culture, as well as in Kazakhstan's Indigenous culture, language, and heritage. Her education in the former Soviet Union, Kazakhstan, and the United States has equipped her with a deep understanding of the value of culture, cultural practices, and the cultural and social value of languages in generating and preserving Indigenous knowledge. She has provided invaluable insights into the role of language in sustaining and passing knowledge from one generation to the next. Her interpretive epistemological view of the world, which places linguistic differences at the center of understanding sociocultural and sociohistorical experiences, guides her work. She focuses on how meaning-making is culturally guided and linguistically varied, and her feedback has been instrumental in refining codes and aligning Indigenous leadership values from a broader Indigenous perspective.

Thus, the data-collection methods were guided by capturing how and what meanings the participants made during and after the PD. Since antiracist and culturally relevant pedagogies were new to the teachers, the researchers specifically focused on how the participants made sense of the engagements and learning during the PD, which were informed by their lived experiences.

16. Findings

Three main findings emerged from the analysis of data collected during and after the PD. The findings indicated the desired characteristics and values of science teacher leaders in the Tharu school, which were as follows: (i) prioritizing Indigenous science content: social and cultural connections; (ii) seeking affirmation from principals on becoming a science teacher leader: managing a dual universe; and (iii) greater willingness to embrace antiracist pedagogy for female participation and Indigenous knowledge.

1. Prioritizing Indigenous Science Content: Social and Cultural Connections

One of the goals of antiracist pedagogy is to highlight the issues of social, cultural, and knowledge discrimination in school curricula, textbooks, policies, and pedagogy. We began the first day of the PD by asking the participants to write down factors that hindered science learning among Indigenous students. Most of the responses were “student motivation”, “poor standard Nepali language skills”, “prioritizing home chores rather than schoolwork”, “lack of science resources”, “no hands-on labs”, and “not understanding science content or thinking that science is hard”. All the responses focused on content mastery and supported dominant cultural preferences, such as the dominance of the Nepali language in textbooks. When asked to consider Indigenous culture, knowledge, history, and the system of bonded labor in their science curriculum and pedagogy, Bimal, a middle school teacher, expressed, “Science is more about ‘hard evidence’ and is true everywhere. I don’t think anything you mentioned is about science”. Akash, a high school teacher, wondered, “I can see how climate change and health and some health practices like home births of children in the Tharu [community] could be linked to science . . . but I don’t know about ‘bonded labor thing.’”

The principals, Mukhiya and Mangal, sought a balance between the science content in the textbooks and Indigenous science knowledge, where social and cultural issues could be infused while teaching science. The goal was to support student learning and better test results. The following quotes captured their balanced views:

Mukhiya: Tharu knowledge in areas like *kulo* making, repairing, River dam building, and recognizing hard and soft wood and their age without cutting down can be part of science texts from Grades 4–10. . . without affecting the national test results. A Tharu student can lead all teachers in this [integrating Tharu knowledge in science].

Mangal: Connect science content like subtropical diseases (sickle, water-borne diseases) and food scarcity (malnutrition from lack of protein) that Tharu students in the village encounter. . . . Grade 9 and 10 science books have to state [that] sickle cell disease is not “Tharu disease”, it is a genetic disease.

Similarly, Maya (a female Tharu teacher) and Bikash (a male Tharu teacher) saw Tharu knowledge missing from elementary and middle school textbooks as unfair. They shared examples of Tharu knowledge that could be part of science textbooks across the grades.

Maya: We store grains (rice and wheat) for seed, and daily consumption in a sizeable Tharu-made container [called *bhakari* and *dehari* in Tharu]. A *bhakari* is built mostly outside the house that is south facing [longer hours of the direct sun] and raised [less chance of flooding] so it gets the most sun and the least moisture. Similarly, a *dehari* is built by women inside the house at a location that is drier to stop the grains from rotting or sprouting. Tharu women and men build *bhakari* and *dehari* from locally available materials such as clay, reed, and straw.

Bikash: Also, when we build *bhakari* and *dehari*, we pray to the spirit to keep it safe till next year. Tharus always thanks the land through spirits of the place and environment such as the jungle, water, air, rain, and ancestors. These are about respecting the climate and uncertain change[s] in weather patterns. . . . All these can be part of life science and environment science in the textbooks.

Maya and Jamuni (other elementary teachers) suggested that teachers could draw from local knowledge of storing water in underground clay pots to keep it cool in the summer in elementary school. In another instance, while discussing how Tharu culture and knowledge could be integrated in elementary and middle school science, Maya, who is a Tharu, and Ruk, a male non-Tharu, supported the value of Tharu culture in science.

Maya: We [Tharu] grow bottle gourds in all homes for the good spirit because bottle gourds represent the spirit of our homes, and they are also used for multiple

purposes like a vegetable, symbol of spirit when we [perform] certain rituals, and use for carrying water when it's dry.

Ruk: I didn't know [one] used it as a symbol of spirit. ... I can use this idea when I teach science and local cultural connections.

During the PD and interview, teachers stated that the value of Tharu's knowledge and culture could be an effective and trustworthy for science teacher leaders. The science teacher leader not only considers Tharu culture and knowledge in classroom instructions but also invests in curriculum that includes the local culture and knowledge.

Bimal: Tharu teachers [science teacher leaders] could lead their school's science teachers to rewrite their curriculum to include local cultures, such as bottle gourds, kulo water supply, and the tradition of using bottle gourds for the spirit.

Rakesh: Tharu culture revolves around farming and harmony with their land. So, there is a lot in environmental science, like climate change and how Tharus have changed irrigation habits based on their knowledge of the land.

However, an elementary teacher, Siddhi, expressed his worry about teaching Tharu science:

Tharus have a different idea of science and are less interested in it. Tharus find science hard because they think that knowing the textbooks or science we teach is less important. I think everything about *kulwak* work and harvesting grass to make ropes is less about school science. ... This will not help them succeed [passing the test and postsecondary education]. ... We need Tharu science teachers who can lead [and teach] mostly school science.

Another middle school teacher, Ruk, expressed similar concerns about Tharu culture, science, and leading the science department. Ruk believed that Indigenous knowledge is not science because that knowledge was not produced through experiments. He further believed that science teacher leaders need not have to focus on Tharu knowledge:

Middle school students need more science knowledge than is in the book because that is what makes Tharu students successful [passing the test and postsecondary education]. They already have local knowledge, like when to plant rice and how much water to irrigate, but that is not what school science is for. Science teachers should help Tharu students do more science experiments and the [science teacher] leaders need to give more training to peers to teach more with experiments. I think I use Tharu knowledge less in science but be a leader in science teaching.

Siddhi and Ruk shared a common concern among Nepali teachers who taught in Indigenous and marginalized student schools. They believed in Western science and its ways of producing knowledge because that was what was assessed in local and national external exams, and high scores in these assessments were the path to postsecondary degrees and potentially good professions.

Overall, most teachers and the principals were supportive of science teacher leaders valuing and knowing the value of Indigenous and Tharu science knowledge.

Bikash: A Tharu teacher leader can bring Tharu science [Indigenous science knowledge], like how we make water carriers from bottle gourds or which tree bark is suitable for making ropes during dam construction. ... We lead by consensus and *nata* [relationship].

Maya: A science teacher leader needs to know Tharu culture for *aguwa* [male leader] and *aginia* [female leader] based on collective agreement. ... We listen to the Tharu spirit and the land to tell us when to do what. ... Our fathers and mothers passed on to us.

Bimal: Tharus have a lot of cultural and local knowledge about the environment. I think a science teacher leader need that here.

Mukhiya: I think *kulwak aguwa* could be a good knowledge source for us and a model. . . . I'm a principal, but I need to work on building relationships. . . . I find it hard to ignore Tharu knowledge of environmental science, and I tell teachers to lead with that in science.

Mangal: Tharu culture is full of rich knowledge, and I have been telling my science teachers to lead with that in class. . . . We need more workshops to do this, and maybe bring Tharu elders, like you did for this workshop.

Most teachers and the principals agreed that local cultural examples would be highly valuable for understanding science and are "equal to science in a textbook", as Navin stated. Also, for all the teachers in this PD, sustainability practices and local land and environment knowledge "could easily replace some of the science textbook illustrations and activities to match the local farming practices and fishing practices and irrigation knowledge", as Mangal said. Bikash and Maya pointed out that Tharus have more than 30 names for types of fishing nets based on river water conditions and the size and type of the person using the net. In some ways, the PD pushed science teachers intentionally to reflect on how local social and cultural connections could be leveraged in science teaching and learning. Mukhiya concluded, "Maybe being a teacher leader of my school means detailing [and dealing with] Tharu culture and the knowledge of the environment and place with science textbooks and tak[ing] the risk. So why not try to bring more Tharu culture and knowledge in science".

2. Seeking Affirmation from Principals on Becoming a Science Teacher Leader: Managing a Dual Universe

Principals hold both the administrative and pedagogical power in schools in a top-down leadership model. This model is contrary to the Tharu model of leadership, which is built on relational virtues and local community needs. Since high school teachers in the PD were apprehensive about student performance on the national exam, they felt pulled in two directions: top-down leadership that controls science pedagogy and content versus a relational model where Indigenous student needs are more central.

Akash: I think a science leader needs to lead the content in the textbook for the test, but then Tharu students can find that science [is] useful. We bring Tharu elders in our school management meetings, and they always say the Tharu way of doing requires *aguwa* to be a consensus person, so we can relate, and I can [call] him *dadu* [father], *bhainay* [brother-in-law], or *dada* [older brother]" [indicating a relationship]. The district chooses our principals, so it's not Tharu way of doing it. . . . We need support from principals to be science [teacher] leaders.

Mangal: In [a] Tharu school, we need to respect that [relational model]. As a principal, I want a science teacher leader who can build the Tharu way of connecting and Tharu culture in science and teach science in [the] textbooks.

Despite understanding the Tharu leadership model and values, teachers wondered if they could lead science departments in their schools with the Tharu way of leading. The teachers in the PD seemed to understand that a science teacher leader who supports antiracist pedagogy in a school needs to incorporate Tharu values and needs strong support from the principal to carry them out successfully.

Maya: Tharus values [are to] choose a leader by all [consensus], but the principal is our leader chosen by the district, which has more power. So at least we can choose a science teacher leader by all. This [science teacher] leader sees us from a relational [point of view]. Hope our principal agrees.

Akash: My principal doesn't think most of the Tharu students are good at science. So, I don't know if my principal would be supporting me. But I know a science teacher leader in my school has to be selected by all and also finds value in

the Tharu way of doing and their knowledge of lots of science-relevant ideas [Indigenous science knowledge].

Navin: Because this [antiracist with cultural value] method of teaching and thinking is new to us, and we have never thought about culture and history in science, this will be a big task. . . . But as a science teacher leader agreed that all could bring Tharu culture, knowledge of so many local environments, and acute skills to see things in nature . . . Tharus recognize weather and directions through dense jungle.

Mukhiya: This [antiracist with cultural value] will demand a lot of change in the thinking of our science teachers. . . . I need to give lots of support to local culture.

Maya: Science leaders [need] to help new teachers, who are appointed here, from other parts of Nepal to learn both Tharu culture and practices.

The discussions among the teachers and principals at the PD indicated that without principal support, there was very little chance for a science teacher leader to value the Tharu way of leading. They also mentioned that in order to build an antiracist science classroom and curriculum successfully, the principal's support would be essential. Some teachers remarked that principals might struggle to change teachers' top-down leadership model, which was less aligned with Tharu values and culture in the current model of leadership practice. The tension between learning Western science from textbooks and Indigenous science and values was present in all the conversations and interviews. Additionally, the teachers felt an ambivalence about how science teacher leaders should encourage peers to be more responsive to local Indigenous knowledge, as well as the science from the textbooks.

3. Greater Willingness to Embrace Antiracist Pedagogy for Female Participation and Indigenous Knowledge

During the PD, all female teachers and Indigenous teachers had positive views about antiracist pedagogy. They felt that the method of teaching science that encouraged Tharu students to have a voice and for teachers to draw from Tharu history, culture, and Indigenous science knowledge aided in learning science that supported the "Tharu way of knowing and doing". During PD discussions and focus group interviews, both groups saw benefits of teaching science that questioned "discrimination present in the textbooks and school system", as Navin stated. The value of antiracist pedagogy focused on science teaching seemed to encourage female teachers. In a small-group discussion, female teachers talked about how the school's start time during summer months did not support girls, specifically Tharu girls:

Balkumari: There could be a [robust] discussion of gender issues, like morning school in the summer to escape from 40-degree [Celsius] heat during the afternoon. Many girls miss early classes because they are helping moms at home. . . . The science teacher leader and principal must consider this and do something.

Maya: Tharu girls are [mainly] busy because they have to take care of siblings and clean the house. A lot of times, they have to run home to bring food to the farm for their parents and anyone working in the field. . . . the science teacher leader must think, and maybe science class [period] is later in the [school day].

Jamuni: Tharu girls are also responsible for substituting their sick or busy mothers if they work as *kamalari* [bonded women laborers] in someone else's home. . . . Most Tharu girls and other girls have [disadvantage] because of morning school. . . . how might a science teacher leader help girls in this case?

The teachers believed that social challenges were pulling the Tharu girls back from science learning. They also raised the health and discriminatory social issue of bonded labor that the larger society and the school needed to consider for Tharu girls. The teachers clearly envisioned a science teacher leader who would find ways to accommodate the needs

of Tharu girls and the social issues connected to attending school. This raised a systemic school system issue, as the principals in the PD reflected on the early class start time and its challenge to Tharu girls' attendance.

Navin: [This is a] system-wide problem [based on] a discriminatory history of the bonded labor system. . .but we can't teach students in such a heat without fans in the classes.

Mangal: We can't change it, because there is no [cooling] system, and [the] electricity supply is intermittent. The heat is too much for students to be in class.

Navin: This [school start time] is a historical government decision that school management follows . . . the bonded labor system, which [continues] as [an] informal and [exploitative] economic activity, primarily disadvantaged girls, who had to help parents at home. [Even though the] government has declared bonded labor practice illegal, a majority of Tharu families still live with its [legacy] in health care, schooling, and food insecurity. Therefore, the [antiracist] teaching approach could help discuss these issues in all science classes [in science] topics like sustainability, heredity, environmental change, and water and land pollution.

The teachers agreed that a science teacher leader needed to focus on local social challenges and the lack of school infrastructure to support girls' school attendance. They also recognized that girls' missing classes were larger than just the school system. It was also about generations of social discrimination. Thus, science teacher leaders could focus on not only teaching science but also historically persistent social issues.

Furthermore, the Tharu teachers and non-Tharu teachers agreed that the Tharu language had to be part of instruction for student success in science. The Tharu teachers acknowledged how valuable Tharu language and place-based knowledge could be for science teachers and, specifically, science teacher leaders when they must lead their peers.

Bikash: Greater cultural and historical connections in science [through] all classes held in bilingual [Tharu and Nepali]. . . You can connect the bonded labor history with the Tharu irrigation and *agurwa* systems.

Jamuni: Tharu women have [mastered] skills to make *dehair* and *bhakari* to store grain for food and seeds. Isn't this *baigyanki* [scientific]? Women have the knowledge to recognize plant roots used for fermenting grains for our Tharu rituals.

Maya: Look at our skills to make fishing nets for all ages because we believe all Tharu people can help find food from an early age. We can bring this knowledge to many science topics. [Doesn't] this make Tharu knowledge *baigyanik* [scientific]?

Prakash: If the principals encourage teachers to be more Tharu aware, including Tharu knowledge, especially in climate issues, it would be very beneficial. It's [Tharu knowledge] like *baigyanki gyan* [scientific knowledge] because they can predict and [anticipate] so many things naturally. Also, Tharus can [make] valuable contributions in a science leadership role with their knowledge and values.

The discussions indicated the recognition of the value of Tharu knowledge and girls' participation in science, and science teacher leaders needed to promote them. The Tharu community's knowledge, as shared by the teachers, was clearly focused on community survival and well-being. However, some teachers expressed concern that Indigenous science knowledge and discussions on sociocultural and discriminatory issues in science would distract from science teaching and learning and, for some, be challenging.

Bimal: I'm Maithali, another linguistically marginalized group in Nepal, so we also have many cultural things and ideas that can be called scientific. However, Maithali students will fail the national Grade 10 test if they write Maithali practices and knowledge in the test. . . So I'm concerned about using Tharu knowledge, which is local because science is all over [universal knowledge]. Also, I'm not from Tharu culture, so it's another burden. But learning new things is

good, but in science, it is different. Science [teacher] leaders need to know science, and culture can be a secondary part but relatable. I have daughters, and I agree the PD, all female teachers and Indigenous teachers had positive views about antiracist pedagogy.

Janak: Maybe more science teaching and experiment ideas [will] help become [science] leaders. We can include some Tharu knowledge as an example but not replace textbook science. Science teacher leaders should be chosen by all, but except [advocating] and doing something to bring more girls; science content shouldn't be replaced by Tharu knowledge of things. . . . Science is global [universal], but Tharu is a local knowledge that I can't use in the hills of Nepal.

Bimal and Janak were worried that the material that might be replaced in the science textbooks would negatively affect student success. They agreed that science teacher leaders had to support girls in science, but they disagreed with making Tharu knowledge a part of science instruction. Similarly, some principals expressed that their biggest challenge and anxiety was how science teacher leaders with hardly any Tharu community experience could teach and lead peers with their own cultural sensitivities in science.

Overall, the teachers seemed to agree that sociocultural issues such as the *kamalari* were an essential part of girls' participation in science. They also agreed that school infrastructure and the system failed to support girl participation, but the female teachers felt that that should be a central part of becoming a science teacher leader. Furthermore, teachers and principals also recognized that there were barriers to overcoming sociocultural and linguistic challenges. Thus, a science teacher leader must recognize and figure out sociocultural, linguistic, and systemic issues if science teaching and learning is to support girls and other marginalized groups that attend the school.

17. Discussions and Implications

A principal or science teacher leader has influential authority on the instruction and curriculum at a school. These leaders can influence significant changes in classroom practices, curricula, and policy [116]. This case study sheds light on how a PD built awareness among school science teachers and principals and encouraged them to be mindful of cultural differences and Indigenous science knowledge. The goal of the PD was to build interest among science teachers to be science teacher leaders and build a capacity to bring awareness among participants about the sociocultural discrimination experienced by the Tharus and the value of Indigenous science knowledge in an antiracist and culturally relevant science class. Research has shown that without deep awareness and appreciation of the contributions of many cultures in knowledge production among school leaders, teachers and principals tend to continue to support discriminatory teaching and leadership practices [117–119]. A lack of awareness among teachers and principals is found in Indigenous schools where Indigenous knowledge, culture, practices, and values hardly receive space in science textbooks and assessments [21,120].

In this study, we found that many teachers and principals, such as Bikash, Maya, and Mukhiya, agree that Tharu science—Indigenous science knowledge—is valid in many instances, such as the irrigation system, grain storage and seed preservation, and the building of dams in large rivers. Furthermore, the principals and teachers agreed that for a science teacher leader, valuing, acknowledging, and actively drawing from the “Tharu way of knowing” is essential for antiracist pedagogy to support learning. However, some teachers, such as Siddhi and Ruk, suggested that valuing Indigenous science knowledge as much as Western science was concerning because success in assessments was measured based on Western science content. Bimal and Janak raised a similar concern because bringing in the Tharu culture and way of knowing in a science class would deviate from what students needed to learn in science. They reasoned that controlled experiments and the universal nature of Western science were not part of Indigenous science knowledge. This finding is similar to other findings in Indigenous science studies, where Western science takes precedence over Indigenous science knowledge and adversely affects student

learning [121–123]. Therefore, the PD seemed to indicate that supporting a science teacher's leadership model that is focused on Indigenous epistemological practices and ontological values seems to produce science teacher leaders who are more attuned to the relational nature of leadership.

The PD was a starting point for a new generation of science teachers and potential school leaders to consider antiracist pedagogy based on Tharu culture, knowledge, and social experiences in science teaching and learning. The teachers in this case were homegrown, and research has shown that homegrown science teacher leaders are more effective than outsiders in leading culturally sensitive and sustaining science learning environments [35,60,124,125]. Research on school leadership has constantly shown that science teacher leaders who are also advocates for antiracist, culturally relevant, critically conscious teaching and curriculum are most likely to succeed in making science learning meaningful, socially just, and equitable to marginalized students [45,126–128]. Science teacher leaders are needed in science education to encourage teachers to support marginalized students' culture and life experiences and disrupt dominant cultural habits and practices.

The leadership frameworks that Tharu and non-Tharu participants in the PD referenced were based on the "Tharu way of doing", "*nata*" (relationship/relational), and consensus-oriented. Teachers mentioned that the process of selecting an irrigation leader (*kulwak aguwa*) in the community could be an important model for selecting a science teacher leader in the school. Teachers also recognized a disconnect between the top-down principal-selection model used by the far-away district office and the Tharu model of relation-based leadership. We also found that the teachers felt that relationship-based science teacher leadership could be more fruitful in antiracist pedagogy by including culture and Indigenous science knowledge. The relational and broad community well-being values [11,67] of the Tharu leaders seemed to encourage many teachers, Tharu teachers in particular, to see connections between social issues and science. For example, the Tharu teachers mentioned bonded labor issues, girls' issues, and women's knowledge about making fishing nets and building grain containers as pathways for antiracist science teaching and leadership. This study shows similar findings to prior studies on Indigenous leadership, where the relationship is the core basis rather than a top-down Western model of individualism [23,129,130].

This study supports Eisenhart's [131] assertion that science teacher leaders need to provide space for both the critique of science and broader engagement with how curricula and textbooks silence marginalized experiences, histories, and cultures. This PD seemed to show that teachers recognized the Tharu culture's marginalization by excluding language and cultural practices from science textbooks and classroom instruction. Additionally, the PD allowed teachers and principals to reflect on the systematic discrimination [132] against Tharu girls because of the early-morning school start time in the hot and dry summer months. Therefore, the PD seemed to show that the teachers who were thinking of taking the science teacher leadership roles were more aware of social, cultural, linguistic, gender, and other forms of discrimination. Furthermore, the Indigenous Tharu teachers and female teachers seemed to be much more critical about the nature of discrimination. They seemed to find antiracist and culturally appropriate pedagogies and thinking to be essential qualities of science teacher leaders. However, studies on U.S. teacher leadership have explored cultural relevancy and historical discrimination as an ancillary aspect of science teacher leadership rather than a central part of being a teacher leader [87,90]. The PD seemed to show that the Western leadership model is culturally inappropriate for teachers in Tharu schools. In the context of science teacher leaders, Hodson and Dennick [133] explored antiracist engagement in science through the history of science, but another PD for science teacher leaders [87,90] lacked a focus on antiracist pedagogy. Therefore, this study adds to the literature on the value of antiracist science teacher leaders based on an Indigenous leadership model. Furthermore, this study supports Lewthwaite's [134] argument that personal and local contexts influence a teacher leader's potential success in an Indigenous school [70] based on an Indigenous leadership framework.

This study showed that principals, despite being selected in a top-down model, could be valuable partners in building an Indigenous model of science teacher leadership. As science teacher leaders in Indigenous schools want to promote antiracist pedagogy in science classrooms, Indigenous values of relationship building, community well-being, and local contextual knowledge [135,136] would be necessary qualities in an antiracist science teacher leader in Indigenous schools. The focus on antiracist pedagogy in the PD seemed to encourage potential science teacher leaders to reflect on, reevaluate, and challenge their assumptions about Indigenous science knowledge, as well as recognize Indigenous values, history, and culture in science teaching and learning. Therefore, in the context of an Indigenous-majority school, the Indigenous leadership framework of valuing relationships and community wellness could be the basis for antiracist and culturally relevant pedagogy that equips science teachers to hold leadership positions and improve their pedagogy for critical science teaching. This study indicated that more focused PD programs are essential to build science teacher leadership capacities geared towards antiracist and culturally relevant science pedagogies built on a relational leadership model.

Author Contributions: Writing—Original draft, B.U.; Writing—Review and editing, S.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The IRB determined that this study meets the criteria for exemption from IRB review [STUDY00006179] on 26 April 2023.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data for this study is available as an aggregated summary from the first author upon request. Data are not publicly available for privacy.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Koirala, K.P. Ethno science practice as indigenous wisdom: Challenges to braiding with western-based school science curriculum. *Diaspora Indig. Minor. Educ.* **2022**, *17*, 270–282. [CrossRef]
2. Marchiondo, L.A.; Myers, C.G.; Kopelman, S. The relational nature of leadership identity construction: How and when it influences perceived leadership and decision-making. *Leadersh. Q.* **2015**, *26*, 892–908. [CrossRef]
3. Upadhyay, B.; Atwood, E.; Tharu, B. Actions for sociopolitical consciousness in a high school science class: A case study of ninth grade class with predominantly indigenous students. *J. Res. Sci. Teach.* **2020**, *57*, 1119–1147. [CrossRef]
4. Dawadi, S. Impact of the Secondary Education Examination (English) on Students and Parents in Nepal. Doctoral Dissertation, The Open University, Milton Keynes, UK, 2019. [CrossRef]
5. Belbase, S. STEAM Education Initiatives in Nepal. *STEAM J.* **2019**, *4*, 7. Available online: <https://scholarship.claremont.edu/steam/vol4/iss1/7> (accessed on 18 June 2022). [CrossRef]
6. Yates, L.; Woelert, P.; Millar, V.; O'Connor, K. *Knowledge at the Crossroads: Physics and History in the Changing World of Schools and Universities*; Springer: Berlin/Heidelberg, Germany, 2017.
7. Blakeney, A.M. Antiracist pedagogy: Definition, theory, and professional development. *J. Curric. Pedagog.* **2005**, *2*, 119–132. [CrossRef]
8. Lawrence, S.M.; Tatum, B.D. White educators as allies: Moving from awareness to action. In *Off/white: Readings on Society, Race, and Culture*; Fine, M., Weiss, L., Powell, L., Wong, M., Eds.; Routledge: London, UK, 1997; pp. 333–342.
9. Sleeter, C. Support for Diverse Students Through Teacher Education Still Needs Presidential Leadership. *J. Teach. Educ.* **2023**, *74*, 188–190. [CrossRef]
10. Fortney, B.; Morrison, D.; Rodriguez, A.; Upadhyay, B. Rethinking equity in science teacher education: Introduction to special issue. *Cult. Stud. Sci. Educ.* **2019**, *14*, 259–263. [CrossRef]
11. Ballard, H.; Calabrese Barton, A.; Upadhyay, B. Community-Driven Science and Science Education: Living in and Navigating the Edges of Equity, Justice, and Science Learning. *J. Res. Sci. Teaching* **2023**, *60*, 1613–1626. [CrossRef]
12. Jeong, S.; Steele, D.; Upadhyay, B. Transforming Communities: Re-imagining the Possibilities Through Equitable Science Teaching. *J. Sci. Teach. Educ.* **2023**, *34*, 437–442. [CrossRef]
13. Spillane, J.P.; Hopkins, M. Organizing for instruction in education systems and school organizations: How the subject matters. *J. Curric. Stud.* **2013**, *45*, 721–747. [CrossRef]
14. Fuentes, Q.S.; Jimerson, J.B. Role enactment and types of feedback: The influence of leadership content knowledge on instructional leadership efforts. *J. Edu. Sup.* **2020**, *3*, 6–31. [CrossRef]

15. Cherubini, L. *Aboriginal Student Engagement and Achievement: Educational Practices and Cultural Sustainability*; UBC Press: Vancouver, BC, Canada, 2014.
16. De Bortoli, L.; Thomson, S. *Contextual Factors that Influence the Achievement of Australia's Indigenous Students: Results from PISA 2000–2006*; ACER Press: Camberwell, Australia, 2010.
17. Moodie, N.; Vass, G.; Lowe, K. Special issue editorial: Systematic reviews in Indigenous education. *Asia-Pac. J. Teach. Educ.* **2021**, *49*, 1–4. [\[CrossRef\]](#)
18. Aikenhead, G.S.; Jegede, O.J. Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *J. Res. Sci. Teach.* **1999**, *36*, 269–287. [\[CrossRef\]](#)
19. Kawagley, A.O.; Barnhardt, R. Education Indigenous to place: Western science meets Native reality. In *Ecological Education in Action: On Weaving Education, Culture and the Environment*; Smith, G.A., Williams, D.R., Eds.; State University of New York Press: New York, NY, USA, 1999.
20. Lowe, K.; Tennent, C.; Burgess, C. School-based Indigenous cultural programs and their impact on Australian Indigenous students: A systematic review. *Asia-Pac. J. Teach. Educ.* **2021**, *49*, 78–98. [\[CrossRef\]](#)
21. Macfarlane, A.; Manning, R.; Ataria, J.; Macfarlane, S.; Derby, M.; Clarke, H.T. Wetekia kia rere: The potential for place-conscious education approaches to reassure the Indigenousization of science education in New Zealand settings. *Cult. Stud. Sci. Educ.* **2019**, *14*, 449–464. [\[CrossRef\]](#)
22. Bang, M.; Medin, D. Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Sci. Educ.* **2010**, *94*, 1008–1026. [\[CrossRef\]](#)
23. Baynes, R. Teachers' attitudes to including Indigenous knowledges in the Australian science curriculum. *Aust. J. Indig. Educ.* **2016**, *45*, 80–90. [\[CrossRef\]](#)
24. Cajete, G.A. *Igniting the Sparkle: An Indigenous Science Education Model*; Kivaki Press: Durango, CO, USA, 1999.
25. Castagno, A.E.; Brayboy, B.M.J. Culturally responsive schooling for Indigenous youth: A review of the literature. *Rev. Educ. Res.* **2008**, *78*, 941–993. [\[CrossRef\]](#)
26. Younging, G. *Elements of Indigenous Style: A Guide for Writing by and about Indigenous Peoples*; Brush Education: Edmonton, AB, Canada, 2018.
27. Manning, R.F. Place-consciousness: The ecological systems model and recurring issues that undermine the teaching of Indigenous histories in New Zealand and Australian schools. *Aust. J. Indig. Educ.* **2017**, *46*, 1–12. [\[CrossRef\]](#)
28. Manning, R.F. Place, Power and Pedagogy: A Critical Analysis of the Status of Te Ātiawa Histories of Place in Port Nicholson Block Secondary Schools and the Possible Application of Place-Based Education Models. Ph.D. Thesis, Victoria University of Wellington, Wellington, New Zealand, 2008. Available online: <http://researcharchive.vuw.ac.nz/handle/10063/1051> (accessed on 8 May 2020).
29. Allen, B. Indigenous epistemologies of North America. *Episteme* **2023**, *20*, 324–336. [\[CrossRef\]](#)
30. Harding, S. Latin American Decolonial Philosophies of Science. *Stud. Hist. Philos. Sci.* **2019**, *78*, 48–63. [\[CrossRef\]](#)
31. Smith, L. *Decolonizing Mentalities: Research and Indigenous Peoples*; Zed Books: London, UK, 2012.
32. Allen, D. Recent Research in Science Teaching and Learning. *CBE—Life Sci. Educ.* **2012**, *11*, 221–225. [\[CrossRef\]](#)
33. Kishimoto, K. Anti-racist pedagogy: From faculty's self-reflection to organizing within and beyond the classroom. *Race Ethn. Educ.* **2018**, *21*, 540–554. [\[CrossRef\]](#)
34. Ladson-Billings, G. Toward a theory of culturally relevant pedagogy. *Am. Educ. Res. J.* **1995**, *47*, 465–491. [\[CrossRef\]](#)
35. Ladson-Billings, G. Culturally relevant pedagogy 2.0: A.k.a. the remix. *Harv. Educ. Rev.* **2014**, *84*, 74–84. [\[CrossRef\]](#)
36. Khalifa, M.A.; Gooden, M.A.; Davis, J.E. Culturally responsive school leadership: A synthesis of the literature. *Rev. Educ. Res.* **2016**, *86*, 1272–1311. [\[CrossRef\]](#)
37. Stewart, J.; Warn, J. Between two worlds: Indigenous leaders exercising influence and working across boundaries. *Aust. J. Public Adm.* **2017**, *76*, 3–17. [\[CrossRef\]](#)
38. Merriam, S.B. *Qualitative Research: A Guide to Design and Implementation*, 2nd ed.; Jossey-Bass: San Francisco, CA, USA, 2009.
39. Miles, M.B.; Huberman, A.M.; Saldaña, J. *Qualitative Data Analysis: International Student Edition*, 4th ed.; Sage: Newcastle upon Tyne, UK, 2019.
40. Harbin, M.B.; Thurber, A.; Bandy, J. Teaching race, racism, and racial justice: Pedagogical principles and classroom strategies for course instructors. *Race Pedagog. J.* **2019**, *4*, 1–37.
41. Fleras, A.; Leonard-Elliott, J. *Multiculturalism in Canada*; Nelson: Baltimore, MD, USA, 1992.
42. Gay, G. *Culturally Responsive Teaching: Theory, Research, and Practice*; Teachers College Press: New York, NY, USA, 2000.
43. Paris, D.; Alim, H.S. What are we seeking to sustain through culturally sustaining pedagogy? A loving critique forward. *Harv. Educ. Rev.* **2014**, *84*, 85–100. [\[CrossRef\]](#)
44. McCarty, T.L.; Lee, T.S. Critical culturally sustaining/revitalizing pedagogy and Indigenous education sovereignty. *Harv. Educ. Rev.* **2014**, *84*, 101–124. [\[CrossRef\]](#)
45. Aikenhead, G.S.; Michell, H. *Bridging Cultures Indigenous and Scientific Ways of Knowing Nature*; Pearson: London, UK, 2011.
46. Upadhyay, B.; Atwood, E.; Tharu, B. Antiracist pedagogy in a high school science class: A case of high school science teacher in an Indigenous high school. *J. Sci. Teach. Educ.* **2021**, *32*, 518–536. [\[CrossRef\]](#)
47. Starck, J.G.; Riddle, T.; Sinclair, S.; Warikoo, N. Teachers are people too: Examining the racial bias of teachers compared to other American adults. *Educ. Res.* **2020**, *49*, 273–284. [\[CrossRef\]](#)

48. Galloway, M.K.; Callin, P.; James, S.; Vimegnon, H.; McCall, L. Culturally responsive, antiracist, or anti-oppressive? How language matters for school change efforts. *Equity Excell. Educ.* **2019**, *52*, 485–501. [CrossRef]
49. Kumashiro, K.K. Toward a theory of anti-oppressive education. *Rev. Educ. Res.* **2000**, *70*, 25–53. [CrossRef]
50. Pugh, P.; McGinty, M.; Bang, M. Relational epistemologies in land-based learning environments: Reasoning about ecological systems and spatial indexing in motion. *Cult. Stud. Sci. Educ.* **2019**, *14*, 425–448. [CrossRef]
51. Upadhyay, B.; Maruyama, G.; Albrecht, N. Taking an active stance: How urban elementary students connect sociocultural experiences in learning science. *Int. J. Sci. Edu.* **2017**, *39*, 2528–2547. [CrossRef]
52. Scheurich, J.J.; Young, M.D. Coloring epistemologies Are our research epistemologies racially biased? *Educ. Res.* **1997**, *26*, 4–16. [CrossRef]
53. Liu, A.Q.; Benson, N.; Liang, K.E.; Rosenkrantz, M.; Malhotra, A.K.; Marchand, M.; Kapoor, V. Exploring barriers to sickle cell disease care in a lower-middle income country – A qualitative exploration of the Tharu perspective in rural Nepal. *Clin. Epi. Glob. Health* **2023**, *22*, 101337. [CrossRef]
54. Snively, G.; Williams, W.L. *Knowing Home: Braiding Indigenous Science with Western Science*; Book 1; University of Victoria: Victoria, BC, Canada, 2018; pp. 2–11.
55. Buck, G.A.; Chinn, P.; Upadhyay, B. Urban and rural science education research: Expanding conceptual tools involving place and context. In *Handbook of Science Education*; Lederman, N., Zeidler, D., Lederman, J., Eds.; Routledge: New York, NY, USA, 2023; Volume III, pp. 359–388.
56. Carter, R.T.; Lau, M.Y.; Johnson, V.; Kirkinis, K. Racial discrimination and health outcomes among racial/ethnic minorities: A meta-analytic review. *J. Multicult. Couns. Dev.* **2014**, *45*, 232–259. [CrossRef]
57. Dowd, A.C.; Bensimon, E.M. *Engaging the “Race Question”: Accountability and Equity in U.S. Higher Education*; Teachers College Press: New York, NY, USA, 2015.
58. Upadhyay, B.; Aleixo, M.B. Community-Initiated Science for Transformative Teaching. *J. Sci. Teach. Educ.* **2023**, *34*, 443–457. [CrossRef]
59. Koirala, P.K. Multicultural classroom teaching in Nepal: Perspectives and practices of a secondary level science teacher. *Cult. Stud. Sci. Educ.* **2021**, *16*, 1163–1182. [CrossRef]
60. Sleeter, K. Reprint: An Invitation to Support Diverse Students Through Teacher Education. *J. Teach. Educ.* **2023**, *78*, 181–187. [CrossRef]
61. Upadhyay, B. Elementary school science teachers’ perceptions of social justice: A study of two elementary teachers. *Equity Excell. Educ.* **2010**, *43*, 56–71. [CrossRef]
62. Weaver, N.H. Urban and Indigenous: The challenges of being a Native American in the city. *J. Community Pract.* **2012**, *20*, 470–488. [CrossRef]
63. Bajracharya, H.; Brouwer, W. A narrative approach to science teaching in Nepal. *Int. J. Sci. Educ.* **1997**, *19*, 429–446. [CrossRef]
64. Mangin, M.M.; Stoelinga, S.R. The future of instructional teacher leader roles. *Educ. Forum* **2009**, *74*, 49–62. [CrossRef]
65. Curtis, R. *Finding a New Way: Leveraging Teacher Leadership to Meet Unprecedented Demands*; Aspen Institute: Washington, DC, USA, 2013.
66. Muijs, D.; Harris, A. Teacher leadership—Improvement through empowerment? An overview of the literature. *Educ. Manag. Adm. Leadersh.* **2003**, *31*, 437–448.
67. Dudgeon, P.; Walker, R.; Scrine, C.; Cox, K.; D’Anna, D.; Dunkley, D.; Kelly, K.; Hams, K. Enhancing wellbeing, empowerment, healing and leadership. In *Working Together: Aboriginal and Torres Strait Islander Mental Health and Wellbeing Principles and Practice*, 2nd ed.; Dudgeon, P., Milroy, H., Walker, R., Eds.; Commonwealth of Australia: Barton, Australia, 2014; pp. 431–447.
68. Gunstone, A. Governance in Australian Universities. *Int. J. Crit. Indig. Stud.* **2013**, *6*, 1–11. Available online: <https://search.informit.org/doi/pdf/10.3316/informit.361934112936718> (accessed on 24 June 2019).
69. Archuleta, M. Approaching leadership through culture, story, and relationships. In *Living Indigenous Leadership: Native Narratives on Building Strong Communities*; Kenny, C., Fraser, T.N., Eds.; UBC Press: Vancouver, BC, Canada, 2012; pp. 162–178.
70. Kenny, C.; Fraser, T.N. *Living Indigenous Leadership: Native Narratives on Building Strong Communities*; UBC Press: Vancouver, BC, Canada, 2012.
71. Chinn, P.W. Decolonizing methodologies and indigenous knowledge: The role of culture, place and personal experience in professional development. *J. Res. Sci. Teach.* **2007**, *44*, 1247–1268. [CrossRef]
72. Dei, G.J.S.; Karanja, W.; Erger, G. The Role of Elders and Their Cultural Knowledges in Schools. In *Elders’ Cultural Knowledges and the Question of Black/African Indigeneity in Education*; Dei, G.J.S., Karanja, W., Erger, G., Eds.; Critical Studies of Education, Springer: Cham, Switzerland, 2022; Volume 16. [CrossRef]
73. Nakata, M. Pathways for Indigenous education in the Australian curriculum framework. *Aust. J. Indig. Educ.* **2011**, *40*, 1–8. [CrossRef]
74. Headrick-Taylor, K.; Silvis, D. *Mobile City Science: Technology-Supported Collaborative Learning at Community Scale*; International Society of the Learning Sciences: Buffalo, NY, USA, 2017.
75. Kincheloe, J.L.; Steinberg, S.R. Indigenous knowledges in education complexities, dangers, and profound benefits. In *Handbook of Critical and Indigenous Methodologies*; Denzin, N.K., Lincoln, Y.S., Smith, L.T., Eds.; SAGE: Newcastle upon Tyne, UK, 2008; pp. 135–156.
76. Sefa Dei, G.J. Indigenous knowledge studies and the next generation: Pedagogical possibilities for anti-colonial education. *Aust. J. Indig. Educ.* **2008**, *37*, 5–13.

77. Bruchac, M. Indigenous knowledge and traditional knowledge. In *Encyclopedia of Global Archaeology*; Smith, C., Ed.; Springer: Berlin/Heidelberg, Germany, 2014; pp. 3814–3824.
78. Upadhyay, B. Using students' lived experiences in an urban science classroom: An elementary school teacher's thinking. *Sci. Educ.* **2006**, *90*, 94–110. [\[CrossRef\]](#)
79. Leithwood, K.; Seashore Louis, K.; Anderson, S.; Wahlstrom, K. *Review of Research: How Leadership Influences Student Learning*; Wallace Foundation: New York, NY, USA, 2004.
80. Wasley, P.A. *Teachers Who Lead: The Rhetoric of Reform and Realities of Practice*; Teachers College Press: New York, NY, USA, 1991.
81. Katzen-Meyer, M.; Moller, G. *Awakening the Sleeping Giant: Helping Teachers Develop as Leaders*, 2nd ed.; Corwin Press: Thousand Oaks, CA, USA, 2001.
82. Boles, K.; Troen, V. Teacher leadership in a professional development school [Paper Presentation]. In Proceedings of the Annual Meeting of the American Educational Research Association, New Orleans, LA, USA, 4–8 April 1994.
83. Wenner, J.A. Urban elementary science teacher leaders: Responsibilities, supports and needs. *Sci. Educ.* **2017**, *25*, 117–125.
84. Foster, L.; Tillman, L.C. *African American Perspectives on Leadership in Schools*; R & L Education: Lanham, MD, USA, 2009.
85. Gooden, M.A.; Dantley, M. Centering race in a framework for leadership preparation. *J. Res. Leadersh. Educ.* **2012**, *7*, 237–253. [\[CrossRef\]](#)
86. Terrell, R.D.; Lindsey, R.B. *Culturally Proficient Leadership: The Personal Journey Begins within*; Corwin Press: Thousand Oaks, CA, USA, 2008.
87. Luft, J.A.; Dubois, S.L.; Kaufmann, J.; Plank, L. Science teacher leadership: Learning from a three-year leadership program. *Sci. Educ.* **2016**, *25*, 1–9.
88. Rhoton, J. *Science Education Leadership: Best Practices for the New Century*; Rhoton, J., Ed.; National Science Teacher Association: Arlington, VA, USA, 2010.
89. Wojnowski, B. Forward. In *Science Education Leadership*; Rhoton, J., Ed.; National Science Teacher Association: Arlington, VA, USA, 2010; pp. ix–x.
90. Hanuscin, D.L.; Rebello, C.M.; Sinha, S. Supporting the development of science teacher leaders. Where do we begin? *Sci. Educ.* **2012**, *21*, 12–18.
91. Howe, A.C.; Stubbs, H.S. From science teacher to teacher leader: Leadership development as meaning making in a community of practice. *Sci. Educ.* **2003**, *87*, 281–297. [\[CrossRef\]](#)
92. National Research Council. *Next Generation Science Standards: For States, by States*; National Academies Press: Washington, DC, USA, 2013.
93. Hofstein, A.; Carmeli, M.; Shore, R. The professional development of high school chemistry coordinators. *J. Sci. Teach. Educ.* **2004**, *15*, 3–24. [\[CrossRef\]](#)
94. Fairhurst, G.; Uhl-Bien, M. Organizational discourse analysis (ODA): Examining leadership as a relational process. *Leadersh. Q.* **2012**, *23*, 1043–1062. [\[CrossRef\]](#)
95. Guerin, B.; Guerin, P. Rethinking mental health for Indigenous Australian communities: Communities as context for mental health. *Community Dev. J.* **2012**, *47*, 555–570. [\[CrossRef\]](#)
96. Helstad, K.; Møller, J. Leadership as relational work: Risks and opportunities. *Int. J. Leadersh. Educ.* **2013**, *16*, 245–262. [\[CrossRef\]](#)
97. Sanders, W. Being a good senior manager in Indigenous community governance: Working with public purpose and private benefit. *Aust. J. Public Adm.* **2008**, *67*, 173–185. [\[CrossRef\]](#)
98. Foley, D. The rise of class culture theory in educational anthropology. *Anthropol. Educ. Q.* **2010**, *41*, 215–227. [\[CrossRef\]](#)
99. Maddison, S. *Black Politics*; Allen & Unwin: Sydney, Australia, 2009.
100. Hofstede, G. Motivation, leadership, and organization: Do American theories apply abroad? *Organ. Dyn.* **1980**, *9*, 42–63. [\[CrossRef\]](#)
101. Coyhis, D. *Wisdom of the People*; White Bison: Colorado Springs, CO, USA, 1995.
102. Wheatley, M.J. *Leadership and the New Science: Learning about Organization from an Orderly Universe*; Berret-Koehler: Oakland, CA, USA, 1992.
103. Wilke, L.A.; Speer, P.W. The mediating influence of organizational characteristics in the relationship between organizational type and relational power: An extension of psychological empowerment research. *J. Community Psychol.* **2011**, *39*, 972–986. [\[CrossRef\]](#)
104. Shanley, J.; Kenneth, R. Wise men and elegant speakers: Reflecting on traditional Assiniboine leadership. *Tribal Coll. J.* **1993**, *5*, 12–15.
105. Julien, M.; Wright, B.; Zinni, D.M. Stories from the circle: Leadership lessons learned from Aboriginal leaders. *Leadersh. Q.* **2010**, *21*, 114–126. [\[CrossRef\]](#)
106. Ruwhiu, D.; Cone, M. Pragmatic leadership: A return to wisdom. *J. Manag. Organ.* **2013**, *19*, 25–43. [\[CrossRef\]](#)
107. Albrecht, N.; Upadhyay, B. What do refugee mothers want in U.S. school science: Learning from the perceptions of science of three Somali mothers. *Urban Rev.* **2018**, *50*, 604–629. [\[CrossRef\]](#)
108. Nkrumah, T. The Inequities Embedded in Measures of Engagement in Science Education for African American Learners from a Culturally Relevant Science Pedagogy Lens. *Educ. Sci.* **2023**, *13*, 739. [\[CrossRef\]](#)
109. Rofo, C.; Moeed, A.; Anderson, D.; Bartholomew, R. Science in an Indigenous School: Insight into Teacher Beliefs about Science Inquiry and their Development as Science Teachers. *Aust. J. Indig. Educ.* **2015**, *45*, 91–99. [\[CrossRef\]](#)

110. Fraise, N.J.; Brooks, J.S. Toward a theory of culturally relevant leadership for school–community culture. *Int. J. Multicult. Educ.* **2015**, *17*, 6–21. [[CrossRef](#)]
111. Stake, R.E. *The Art of Case Study Research*; Sage: Newcastle upon Tyne, UK, 1995.
112. Yin, R.K. *Case Study Research and Applications: Design and Methods*, 6th ed.; Sage: Newcastle upon Tyne, UK, 2018.
113. Creswell, J.W. *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, 4th ed.; Sage: Newcastle upon Tyne, UK, 2014.
114. Bogdan, R.C.; Biklen, S.K. *Qualitative Research for Education: An Introduction to Theory and Methods*; Allyn and Bacon: Boston, MA, USA, 1982.
115. DeSantis, L.; Ugarriza, D.N. The concept of theme as used in qualitative nursing research. *West. J. Nurs. Res.* **2000**, *22*, 351–372. [[CrossRef](#)]
116. Branch, G.F.; Hanushek, E.A.; Rivkin, S. School leaders matter. *Educ. Next* **2013**, *13*, 62–69.
117. Freire, P. *Pedagogy of the Oppressed*; Bloomsbury: London, UK, 2000.
118. Gay, G.; Kirkland, K. Developing cultural critical consciousness and self-reflection in preservice teacher education. *Theory Into Pract.* **2003**, *42*, 181–187. [[CrossRef](#)]
119. Khalifa, M. A re-new-ed paradigm in successful urban school leadership principal as community leader. *Educ. Adm. Q.* **2012**, *48*, 424–467. [[CrossRef](#)]
120. Marin, A.; Bang, M. “Look it, this is how you know”: Family forest walks as a context for knowledge-building about the natural world. *Cogn. Instr.* **2018**, *36*, 89–118. [[CrossRef](#)]
121. Bang, M. A case study: Learning gardens in an urban indigenous community: Expanding the scope of learning. In *Sowing Seeds in the City*; Brown, S., McIvor, K., Snyder, E.H., Eds.; Springer: Berlin/Heidelberg, Germany, 2016; pp. 257–268.
122. Shirley, V.J. Indigenous Social Justice Pedagogy: Teaching Into the Risks and Cultivating the Heart. *Crit. Ques. Educ.* **2017**, *8*, 163–175.
123. Simpson, L.B. Land as pedagogy: Nishnaabeg intelligence and rebellious transformation. *Decolonization Indig. Educ. Soc.* **2014**, *3*, 1–25.
124. Corcoran, S.P.; Schwartz, A.E.; Weinstein, M. Training your own: The impact of New York City’s Aspiring Principals Program on student achievement. *Educ. Eval. Policy Anal.* **2012**, *34*, 232–253. [[CrossRef](#)]
125. Madhlangobe, L.; Gordon, S.P. Culturally Responsive Leadership in a Diverse School: A Case Study of a High School Leader. *NASSP Bull.* **2012**, *96*, 177–202. [[CrossRef](#)]
126. Cashman, A.K. Aloha Kumu, Aloha ‘Āina: A graduate program to prepare teacher leaders for the health, well-being, and prosperity of Lāhui Hawai‘i. In *Promising Practices in Indigenous Teacher Education*; Whitinui, P., de France, C.R., McIvor, O., Eds.; Springer: Berlin/Heidelberg, Germany, 2018; pp. 251–263.
127. Criswell, B.A.; Rushton, G.T.; McDonald, S.P. A clearer vision: Creating and evolving a model to support the development of science teacher leaders. *Res. Sci. Educ.* **2018**, *48*, 811–837. [[CrossRef](#)]
128. Ospina, S.; Foldy, E. A critical review of race and ethnicity in the leadership literature: Surfacing context, power and the collective dimensions of leadership. *Leadersh. Q.* **2009**, *20*, 876–896. [[CrossRef](#)]
129. Kanu, Y. *Integrating Aboriginal Perspectives into the School Curriculum*; University of Toronto Press: Toronto, ON, Canada, 2011.
130. Yemini, M.; Engel, L.; Simon, A.B. Place-based education—A systematic review of literature. *Educ. Rev.* **2023**, *75*, 1–21. [[CrossRef](#)]
131. Eisenhart, M. Boundaries and selves in the making of ‘science’. *Res. Sci. Educ.* **2000**, *30*, 43–55. [[CrossRef](#)]
132. Billiot, S.; Kwon, S.; Burnette, C.E. Repeated Disasters and Chronic Environmental Changes Impede Generational Transmission of Indigenous Knowledge. *J. Fam. Strengths* **2019**, *19*, 11. [[CrossRef](#)]
133. Hodson, D.; Dennick, R. Antiracist education: A special role for the history of science and technology. *Sch. Sci. Math.* **1994**, *94*, 255–262. [[CrossRef](#)]
134. Lewthwaite, B. Constraints and contributors to becoming a science teacher-leader. *Sci. Educ.* **2006**, *90*, 331–347. [[CrossRef](#)]
135. Basso, K.H. *Wisdom Sits in Places*; University of New Mexico Press: Albuquerque, NM, USA, 1996.
136. Gruenewald, D.A. Place-based education: Grounding cultural responsive teaching in geographical diversity. In *Place-Based Education in the Global Age: Local Diversity*; Gruenewald, D.A., Smith, G.A., Eds.; Lawrence Erlbaum Associates: Mahwah, NJ, USA, 2008; pp. 137–153.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.