Journal of Culture and Values in Education

https://cultureandvalues.org

E-ISSN: 2590-342X

Volume: 8 Issue: 1 2025

pp. 166-187

Conceptualizing Culturally Responsive Science Teaching within a Values-driven Curriculum Perspective: Utilizing Ubuntu and Eziko as Indigenous Theoretical Frameworks

Eyitayo Julius Ajayi[a]

a. Science Education, Education, University of Johannesburg, South Africa.
Email: 223223921@student.uj.ac.za

Article Info
Received: May 3, 2024
Accepted: November 18, 2024
Published: March 6, 2025

10.46303/jcve.2025.10

How to cite
Ajayi, E. J. (2025). Conceptualizing Culturally Responsive Science Teaching within a Values-driven Curriculum Perspective: Utilizing Ubuntu and Eziko as Indigenous Theoretical Frameworks. *Journal of Culture and Values in Education*, 8(1), 166-187.
https://doi.org/10.46303/jcve.2025.10

Copyright license
This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International license.

ABSTRACT
Current literature expeditions re-echo earlier sentiments among teacher education scholars on the need to make classroom science teaching culturally sensitive. However, there is a scarcity of studies that comprehensively incorporate culture as a structural and mechanistic influence informing research and policies in science education. Against the background of a values-driven perspective of the National Curriculum Statement (NCS), the article proposes a novel approach to understanding culturally responsive science teaching (CRST) within the South African educational context by examining it through the lens of Indigenous cultural values, specifically Ubuntu and Eziko. In this context, Indigenous theories such as Ubuntu and Eziko, which are deeply intertwined with cultural values, offer valuable perspectives for conceptualizing CRST. As an Indigenous African philosophy, Ubuntu embodies a collection of knowledge, values, and practices to enhance human interconnectedness and dignity. Similarly, Eziko emphasizes the spirit of connectedness, humility, and respect, facilitating the co-creation of new knowledge. Suggestions were given for the meaning-making of these cultural values in terms of their Indigenous underpinnings in relation to CRST within the context of a science classroom. Through examples and theoretical insights, the article demonstrates how incorporating Ubuntu and Eziko principles into science teaching practices can enhance student learning outcomes and promote fundamental values enshrined in the post-apartheid South African Constitution. Overall, the article presents a holistic view of CRST that acknowledges the cultural nuances inherent in educational settings, particularly in South Africa. It underscores the importance of incorporating Indigenous cultural values into science education for more meaningful learning experiences.

KEYWORDS
Culturally responsive science teaching; cultural values; Eziko; National Curriculum Statement (NCS); Ubuntu; science education.

INTRODUCTION

The existing literature reflects a growing concern among scholars in teacher education regarding the necessity for science teaching to be culturally responsive (Hernandez & Burrows, 2021). This emphasis is further underscored by a curriculum perspective deeply embedded within the National Curriculum Statement, Grades R-12 (NCS), which encompasses the Curriculum Assessment and Policy Statement (CAPS) and is currently utilized for teaching and learning in South African schools (Department of Basic Education [DBE], 2011). The curriculum perspective prioritizes the recognition of Indigenous knowledge systems (IKS) as integral to "acknowledging the rich history and heritage of [South Africa] as important contributors to nurturing the values contained in the Constitution" (DBE, 2011, p. 4). Notably, the NCS and the post-apartheid South African Constitution are grounded in ten fundamental values that serve as guiding principles (DBE, 2011; Dube, 2023). These values, encompassing democracy, social justice, equity, non-racism, non-sexism, Ubuntu (human dignity), an open society, accountability, respect, the rule of law, and reconciliation (Department of Education [DoE], 2001; Dube, 2020), form the bedrock of educational and societal frameworks. Values are generally conceptualized as beliefs, principles, and standards that shape decision-making and behavior (Kluckhohn, 1951; Mthimkhulu, 2024; Nkambule, 2023; Schwartz, 2012; Seewann & Verwiebe, 2020). This characterization encapsulates the role of *Ubuntu* and *Eziko* (or *eZiko*) in this article as values that underscore interconnectedness and influence human conduct. In alignment with the curriculum perspective, the NCS mandates that learners comprehend the diverse cultural contexts from which IKS emerged, with selected examples reflecting the diversity of South African cultural groups (DBE, 2011, p. 17). This underscores the promotion of culturally responsive science teaching (CRST), mainly through the integration of Indigenous knowledge (IK) into science education. Gay (2018) considers CRST as leveraging students' cultural knowledge and experiences to enhance learning relevance and effectiveness of science teaching. Khosrowjerdi and Bornmann (2021) emphasize the dynamic relationship between cultural knowledge and science, highlighting the crucial role of CRST.

Parsons and Carlone (2013) noted a scarcity of studies that comprehensively incorporate culture as a structural and mechanistic influence informing research and policies in science education. Despite efforts to promote CRST, the sociocultural realities of teaching in South Africa are still overshadowed by the legacies of colonialism and apartheid (Marschall, 2019). IKS have been marginalized, with Western methodologies often taking precedence, neglecting CRST (Kovach, 2009). It is imperative to address this gap to facilitate meaningful, context-based learning and foster cultural sustainability among learners (Handayani et al., 2018; Yeseraw et al., 2023). Given the critical importance of CRST in enhancing cultural entrenchment and relevance in classroom teaching (Wallace et al., 2022; Gay, 2018; Hernandez & Burrows, 2021), it is essential to explore how cultural values and philosophies can inform this pedagogical approach. Indigenous standpoint theory (IST), as articulated by Nakata (2007), offers a theoretical framework deeply rooted in IKS, providing insights into culturally relevant

pedagogical practices (Coates et al., 2023). IST acknowledges the subjective positioning of researchers within their social, cultural, and political contexts, thus informing research methodologies and outcomes (Coates et al., 2023). In this context, Indigenous theories such as *Ubuntu* and *Eziko*, which are deeply intertwined with cultural values, offer valuable perspectives for conceptualizing CRST. As an Indigenous African philosophy, Ubuntu embodies a collection of knowledge, values, and practices to enhance human interconnectedness and dignity (Mugumbate et al., 2023). Similarly, *Eziko* emphasizes the spirit of connectedness, humility, and respect, facilitating the co-creation of new knowledge (Goduka, 2005). However, despite these Indigenous frameworks, the dominance of Western ideologies continues to marginalize Indigenous ways of knowing, necessitating a renewed focus on CRST (Kovach, 2009).

Objectives and rationale: In light of the above considerations, this article proposes an exploration of CRST grounded in socially mediated cultural contexts within the science classroom. Through the lens of culturally relevant values and philosophies, the study offers insights into effective pedagogical approaches that align with the earlier-mentioned perspective of the South African school curriculum. Interest in science subjects can wane when these subjects are taught in isolation, disconnected from real-world applications and the learners' broader cultural contexts (Kelley & Knowles, 2016). Indigenous learners, in particular, face unique cultural and educational challenges that require specialized support (Battiste et al., 2002). Their traditional learning approaches often differ significantly from mainstream educational methods, leading to a disconnection from the formal education system (Kovach, 2010). Additionally, the ongoing effects of colonization—such as cultural trauma, language loss, identity erosion, and socio-economic disadvantages—further compound these challenges (Tuck & Yang, 2012). As a result, teachers may overlook the cultural relevance of science topics, leading to a lack of integration of IK in classroom science instruction. This disconnect hinders learners from experiencing meaningful, context-based learning and undermines cultural sustainability (Yeseraw et al., 2023). In response, this study seeks to conceptualize CRST, grounded in the Indigenous theoretical frameworks of *Ubuntu* and *Eziko*.

LITERATURE REVIEW

The Concept of Value(s)

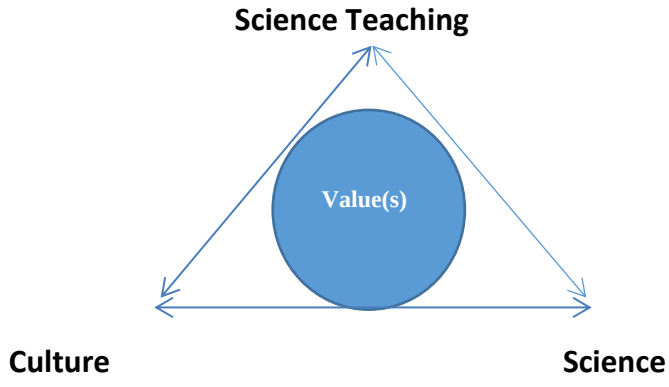
Values are inherently abstract, as noted by Frese (2015), and are often described as "complex and often hard to grasp" (Seewann & Verwiebe, 2020, p. 1). As one of the pioneers in value research, Kluckhohn (1951) delineated value(s) as a concept encompassing an individual's or group's perception of the desirable, which shapes their choices and actions. However, the notion of value(s) has been subject to diverse interpretations (Askeland, 2020). These interpretations, echoing the literal definition of value(s) as the significance or worth of something to an individual, highlight its intangible and abstract nature (Kostrova, 2018). Kostrova (2018) further posited that value(s) are often perceived based on idealized notions rather than empirical observations, suggesting a subjective lens in understanding them. The

literature converges on several key parameters defining values: they "(1) are either explicitly or implicitly contextual (spatial and temporally situated); (2) serve to mobilize for and direct action; (3) are not observable but manifested in or as the valuation of practice; (4) are acquired through socialization into group values yet changeable through experiential learning; (5) are constituted, maintained and changed in dialectical interaction between the individual and his or her social collective and (6) even when shared they are ambiguous and open for interpretation" (Askeland, 2020, p. 26). In all, value(s) lack a physical presence, and this renders them unobservable or intangible (Askeland, 2020).

However, values profoundly influence an individual's actions, thoughts, and decision-making processes, directly shaping behaviors and decisions (Gamage et al., 2021; Khathi et al., 2022; Ndiangui, et al., 2024; Skimina et al., 2019). Thus, the values an individual embraces or disregards manifest in and evoke specific behaviors. Indeed, "…values are synonymous with behaviors" (Bonow & Follett, 2009, p. 73). In alignment with this understanding, I propose a working definition of value(s) as conceptions of desirable trans-situational behavior, objectives, and ideals, guiding and evaluating practices (Askeland, 2020). This definition resonates with the ethos of the ten fundamental values enshrined in the Constitution of South Africa, which aims to foster a society grounded in democratic values and social justice (Preamble, Constitution of South Africa, Acts 108 of 1996). Similarly, the Indigenous philosophies of *Ubuntu* and *Eziko* reflect core African values, emphasizing interdependence and humanness (Goduka, 2005; Chigangaidze et al., 2022). These worldviews underscore communal ethics prevalent in African societies, influencing individuals' interconnectedness within their communities and their perspectives on various aspects of life. Figure 1 illustrates how culture, science, and science teaching are intertwined as value-driven endeavors (Roccas & Sagiv, 2017). Culture, acting as a repository of values, moderates the relationship between values and behavioral meanings. In this context, culture, science, and science teaching emerge as social endeavors shaped by values, guiding individuals' practices within these domains. This interconnectedness underscores the significance of considering *Ubuntu* and *Eziko* in conceptualizing CRST within diverse societal contexts, such as school classrooms.

Figure 1.

Value(s) interlink culture, science, and science teaching (Roccas & Sagiv, 2017)



Culture and Science – Values-driven Endeavors

Various conceptualizations of culture are evident in the literature (Raeff et al., 2020). According to these scholars, culture encompasses customs, values, belief systems, and social relationships that shape the lives and behaviors of specific groups of people. Consequently, culture encompasses all aspects of a group's existence, including philosophy, history, education (teaching and learning), and science, constituting essential cultural heritage components (Raeff et al., 2020). Ogunniyi (2015) describes cultural heritage as encompassing tangible and intangible representations of a community's value systems, beliefs, practices, and way of life from ancient times to the present. As a fundamental aspect of socialization and enculturation, culture provides a concrete foundation for individuals to adopt the values prevalent in their respective contexts. Each culture harbors its own set of values, shaping the upbringing of individuals within families, groups, and society. Such enculturation often manifests in individuals' values-driven choices, decisions, and behaviors over time (Ogunniyi, 2020). The uniqueness and individuality of each sociocultural milieu are intricately linked to the values embedded in and embraced by its social actors.

Similarly, science is an integral component of the cultural heritage of all nations (DBE, 2011) and is imbued with values (Douglas, 2023). Douglas (2023) asserts that social and ethical values are indispensable to the practice of science. The engagement with science is influenced by the cultural milieu in which it is practiced, shaping what is known as the 'culture of science,' including IK specific to that culture. This IK encompasses traditional, native, or local knowledge esteemed by Indigenous peoples (Zidny et al., 2020). Given that each culture embodies a repertoire of values, it follows that science practiced within that culture reflects these values. Allchin (1999) contends that the scientific enterprise is inevitably situated within a particular culture, with values permeating science through its practitioners, consciously or unconsciously. Consequently, practitioners (including science teachers) imbue science with values that uphold its true essence as a cultural heritage within society (Panayotova, 2023). Ogunniyi (2020) argues that science is Indigenous to various cultures and reflects the values inherent in each. Moreover, *'Ubuntu'* and *'Eziko*,' as IK values, are integral to the subculture of science (and science teaching) in Africa. Therefore, science, or its teaching, is a crucial aspect of cultural heritage (Piñar & Sterflinger, 2021) and embodies a cultural connectedness (Herstein, 2022), both driven by values. The focal point of this article is conceptualizing CRST within school classrooms, considering the values-driven nature of culture and science, and utilizing values-driven Indigenous theoretical frameworks.

Culturally Responsive Science Teaching

Culture plays a vital role in teaching activities within educational contexts. Culture is fundamental to culturally responsive teaching (CRT), and it encompasses learners' diversity, lived experiences, and cultural strengths (Giorgetti et al., 2017). According to Thomas and Tripp (2020), culturally responsive teaching comprises a "comprehensive pedagogy predicated on the notion that culture directly impacts teaching and learning and plays an essential role in the way

we communicate and receive information" (p. 772). Therefore, culturally sensitive classrooms (CSC), where CRT takes place, are diverse social environments that bring together teachers and learners from various sociocultural backgrounds. A CSC is a social context involving social actors, teachers, and learners interacting and engaging within a culturally responsive teaching and learning environment. Given this, CRT is a "student-centered approach to teaching that includes cultural references and recognizes the importance of students' cultural backgrounds and experiences in all aspects of learning" (Samuels, 2008, pp. 22-23). Globally, the support for CRT is increasing (Brown et al., 2022), and as a culturally diverse country (Dube, 2023), post-apartheid South Africa is most amenable to such experiences. Accordingly, CRST connotes how 'science,' being a cultural acquisition itself (Khosrowjerdi & Bornmann, 2021), is taught with the perspective of CRT. Since "every teacher faces diversity in the classroom" (Hernandez & Burrows, 2021, p. 338), CRST is germane to ensure learners' enrichment and engagement (Samuels, 2008). In this regard, teachers should be encouraged to help learners experience learning encounters where cultural diversity is valued.

Therefore, I describe CRST as teaching and learning science, which considers specific knowledge that is socioculturally mediated and creates a practicing culture of science (Mhakure & Otulaja, 2017). Additionally, CRST includes Indigenous science or local knowledge (Brown et al., 2018). This formed the premise upon which culturally responsive, sometimes called culturally relevant or culturally sensitive (Ogunniyi, 2020) science teaching is considered in this article. This underlines the curriculum perspective in focus which further expounds in the CAPS for Life Sciences that "learners should understand the different cultural contexts in which IKs were developed [and that] the examples of IK that are selected for study should, as far as possible, reflect different South African cultural groups [and] should also link directly to specific areas" (DBE, 2011 p. 10) in the subject. For this noble objective to be achieved, teachers become culture brokers in the classroom to "achieve culturally sensitive curriculum and assessment" (Jegede & Aikenhead, 1999, p. 45). Against this background, the article conceptualizes CRST based on a values-driven curriculum perspective using the cultural values of *Ubuntu* and *Eziko* as Indigenous theoretical frameworks.

THEORETICAL FRAMEWORK

This article adopts the IST as a theoretical perspective for conceptualizing CRST. The IST is guided by an Indigenous perspective (Nakata, 2007) and considers the 'Indigeneity' of the researcher (Foley, 2003). It "integrates and advances the cultural knowledge and experiences of Indigenous scholars in a way non-Indigenous scholars cannot" (Coates et al., 2023, p. 906). In other words, the IST provides a framework for Indigenous inquiry, which considers peoples' Indigenous ways of knowing based on their lived experiences. IK "provides specific views of the world held by various Indigenous peoples [and] it offers different views on nature and science that generally differ from traditional Western science" (Zidny et al., 2020, p. 145). Kovac (2009) argued that 'Western' research methodologies have obstructed the IK methodologies of Indigenous people.

Hence, western methodologies do not take cognizance (Indigenous worldviews and priorities) of the experiences rooted in Indigenous methodologies (Moreton-Robinson & Walter, 2009). Accordingly, Zidny et al. (2020) reported that there is a need for a robust reflection on how to incorporate Indigenous worldviews into science teaching and learning. Similarly, the relevance of science teaching (and learning) can only be appreciated should they be based on everyday experiences derived within sociocultural contexts (Østergaard, 2017). The IST considers in-depth culturally relevant knowledge embedded within culturally inclined endeavors such as CRST.

Consistent with the above, Østergaard (2017) stated that science teaching (and learning) should be predicated on learners' worldviews undergirded by their lived experiences. This is pertinent because, through their lived experiences, learners bring with them into the classroom different funds of knowledge derived from their sociocultural backgrounds (Upadhyay, 2005). This forms the basis upon which the IST underpins the conceptualization of CRST in this article. According to Coates et al. (2023), a conceptual or theoretical "framework for Indigenous inquiry […] acknowledges the Indigenous perspective, to offer a new lens in which the Indigenous experience within institutions can be interpreted and analyzed" (p. 2). In essence, the IST provides the basis for the use of Indigenous perspectives as a vital instrument and provides a cultural element for theoretical research in IK. Consequently, the Indigenous values of *Eziko* and *Ubuntu* offer the cultural element (Indigenous frameworks) or standpoint theories through which CRST is examined in this article. Informed by and rooted in an African Indigenous worldview, Goduka (2005) proposed a theoretical framework referred to as "*eZiko* Sipheka Sisophula (*eZiko* [or Eziko] *for short*)" (Goduka, 2013, p. 1). According to Goduka (2005), the framework, underscored by an Indigenous philosophical background and cultural values, is relevant to culturally responsive teaching and research. Hence, Goduka (2005) used "eziko to indicate interactive/participatory learning/research processes and practices around which to engage participants in the activities of sipheka (we cook), sisophula (and dish out) [while] iziko denotes a fireplace or space" (p. 59). From Goduka's (2005) postulations, the fireplace (iziko) represents a social context where certain social engagements and interactions occur, including sipheka and sisophula. These social activities, entrenched within the social milieu where the iziko is situated, bring about interdependence and interrelatedness.

Supporting this viewpoint, Goduka (2005) asserts that "around eziko, [there] exists the spirit of connectedness, humility, and respect that affirm diverse stories participants bring and validate new knowledge they co-create" (p. 58). In essence, everyone who has been shaped by the values prevalent in the environment surrounding the fireplace brings those values with them. Hence, the interactions and engagements (e.g., storytelling, dancing, folktale, etc.) among the participants around the iziko facilitate and foster interconnectedness and interrelatedness. These are exemplified through the teaching processes that accentuate the "co-creation and validation of new knowledge" (Goduka, 2005, p. 59) while the activities occur. Hence, as collaborators in knowledge creation, the interconnectedness and interdependence among

participants foster Ubuntu. Ubuntu embodies a foundational philosophy among Black people of Africa, encompassing shared knowledge, values, and practices that signify interconnectedness (Mugumbate et al., 2023). Summarized in South Africa's Nguni language as '*umuntu ngumuntu ngabantu'*—meaning 'a person is a person because of/or through other people'—Ubuntu underscores the interconnectedness between individuals (Ewuoso & Hall, 2019; Mlondo, 2022; van Breda, 2019; Mugumbate, 2020). According to Chigangaidze et al. (2022), Ubuntu serves as a framework illustrating the interconnectedness between people, emphasizing a worldview where individuals see themselves through others. It encompasses Indigenous values and cultural heritage, emphasizing interdependence as essential for human completeness, where each person is influenced by others (Mugumbate & Nyanguru, 2013). This perspective is reinforced by the communal lifestyle prevalent among African peoples (Ilimi, 2014). Ubuntu embodies the value of humaneness, as the inherent interconnectedness among individuals leads each person to seek the well-being of others and vice versa.

METHODOLOGY

Research Design

The Jaakkola (2020) approach to research design for conceptual papers was adopted to foreground the methodological requirements employed in this article. In conceptual papers, arguments are not derived from traditional data but from the assimilation and combination of evidence-based on previously developed concepts and theories (Hirschheim, 2008). Thus, while conceptual papers do not depend directly on empirical data, they are informed by a domain theory (or theories) developed and tested through empirical research (Jaakkola, 2020). The conceptual paper that is currently presented pertains to theory synthesis, which deals with conceptual integration across one or more theoretical perspectives (Jaakkola, 2020). Hence, the starting point for determining the research design employed in conceptual papers is to state the *focal phenomenon* in relation to the domain theory (or theories). This informs the *theory synthesis* type of conceptual paper (Becker & Jaakkola, 2020). Therefore, the data collected and analyzed in a conceptual paper are underlined by the key components/concepts underlying the philosophical underpinnings of the theories selected concerning the phenomenon. To conceptualize the focal phenomenon, I explicate the role of the conceptual components/concepts of the theories in relation to those of the phenomenon. Accordingly, the following research design elements in conceptual paper were adapted and enunciated in expounding the research design employed: (i) Choice of theory(ies) in relation to the focal phenomenon or concept; (ii) Data analysis (Unit of analysis): Perspective/level(s) of analysis/aggregation in relation to key components/elements to be analyzed/explained or used to analyze/explain; and (iii) Translating the target phenomenon into conceptual language and integrating the components/elements with argumentation (Becker & Jaakkola, 2020).

Research design element 1: Choice of domain theories in relation to the focal phenomenon or concept

This element identifies and defines the target phenomenon, while a relevant theory (or theories) that can provide a suitable framework(s) for understanding the phenomenon is selected. The theory should have components (concepts, principles, variables) that can be applied to the target phenomenon (Jaakkola, 2020). In this regard, CRST is the focal phenomenon in relation to the domain theories of *Ubuntu* and *Eziko* (or *eZiko*). Plausibly, the selection of these domain theories is guided by their relevance to the focal phenomenon and their value in conceptualizing it (Jaakkola, 2020). I conceptualize CRST by considering the *eZiko* as a scientific and sociocultural theory. Using the three components of *iziko, sipheka (we cook), and sisophula (and dish out)*—within the *eZiko* (or *Eziko*) framework, I propose a framework for CRST. The *iziko* represents a traditional open fireplace, typically composed of stones or bricks arranged to create a fire, providing warmth, light, and a focal point for social interaction and cultural development (Sorensen, 2019; Karlsson et al., 2020). This fireplace holds cultural significance, with fire historically playing a central role in human evolution and Indigenous South African Khoisan communities' sociocultural practices (Verbuyst, 2022). Humphrey et al. (2021) noted that fire has been integral to cultural practices worldwide, serving as a livelihood and land management tool. Around the fireplace, families engage in various activities such as cooking, sharing meals, storytelling, and dancing, fostering a sense of community and interconnectedness as depicted by the Khoisan family, recognized as the first Indigenous settlers in South Africa (Burnett et al., 2023) (Figure 2). The *Eziko*, rooted in Indigenous worldviews and cultural values, facilitates this interconnectedness among participants (Goduka et al., 2013).

Figure 2.

The Khoisan family gathers around a fire made within the fireplace (iziko) to cook (sipheka), sisophula (share cooked food), dance, and tell stories and folklore.

Inspired by Ubuntu, the spirit of interconnectedness experienced around the fireplace underscores the fundamental principle that each person's existence is intertwined with others (Mathebula & Martinez-Vargas, 2023). This reciprocity between individuals is essential to the activities conducted at the iziko, where tasks are shared among participants, emphasizing the realization of one's essence in relation to others. As a social ethic, Ubuntu guides how people engage with one another, highlighting our moral obligations towards others (Molefe, 2016). Its essence is most pronounced in communal settings, where individuals collectively contribute to shared activities rather than in environments that prioritize individualism (Molefe, 2016). Therefore, understanding and embracing Ubuntu within CRST frameworks enriches educational practices, fostering inclusive and collaborative learning environments rooted in cultural values and interconnectedness—column one of Table 1 (see appendix) below lists the domain theories and their key components/concepts.

Research design element 2: Perspectives of analysis in relation to key components or concepts to be analyzed or used to analyze

This research design element showcases how the key components/concepts within the theories are analyzed in relation to the phenomenon. Considering this, I break down the theory components by dissecting the chosen theories into their core components. The concepts represent the fundamental ideas or variables that the theory addresses. Hence, through this research element, I describe the general rules or laws derived from the theories while proposing the statements that describe relationships between the concepts. In this case, components/concepts situated within the two theories are enunciated further in terms of how CRST is conceptualized. In essence, each component in the *Eziko* (or *eZiko*), that is, *iziko, sipheka,* and *sisophula,* are analyzed with respect, not only to their cultural implications but their relevance to IK of science. Similarly, the component of 'interdependence' is analyzed in a way that depicts how it underscores the theory of *Ubuntu* in relation to its cultural significance and how CRST is conceptualized. In this way, CRST is conceptualized with respect to how it is subsumed within cultural affinities while understanding it is underscored by the tenets of the two Indigenous theoretical frameworks. Column two in Table 1 below presents the perspectives of analysis in relation to key components/concepts to be analyzed or used to analyze in terms of analysis of the domain theories and their key components/concepts.

Research design element 3: Translating the target phenomenon into conceptual language and integrating the components or concepts with argumentation

Through this element, I map the phenomenon to the concepts espoused by the theories. This is to identify how the phenomenon aligns with or can be explained by the theory's concepts. Propositions are formulated to connect the theory's concepts to the aspects of the phenomenon. This step involves arguing how the principles that underlie the theories explain or predict CRST. *Augmentation* ensures a rationale for why the chosen theories and their components are appropriate for translating the phenomenon. It also provides evidence(s) or

reasoning supporting the theories' applicability. By *integration*, I demonstrate how the theory's concepts and principles integrate seamlessly with the phenomenon by offering logical reasoning and examples. Ultimately, I discuss the *implications* of this translation for understanding the phenomenon better, predicting future occurrences, or guiding interventions. Column three in Table 1 below showcases the translation of the target phenomenon into conceptual language and how the components are integrated with augmentation in relation to the focal phenomenon. Moreover, subject-specific classroom CRST is conceptualized in terms of how it relates to components or concepts within the theories.

DISCUSSION AND CONCLUSION

The article proposes a novel approach to understanding CRST within the South African educational context by examining it through the lens of Indigenous cultural values, specifically *Ubuntu* and *Eziko*. This is against the background of a values-driven Indigenous perspective of the NCS, Grades R-12, and the currently used South African school curriculum. Suggestions were given for the meaning-making of these cultural values in terms of their Indigenous underpinnings in relation to CRST within the context of a science classroom. This kind of effort helps to "integrate Indigenous ways of knowing in the academy, that include knowledge construction, ways of teaching, learning, and conducting research" (Goduka, 2005, p. 70). I argue that the classroom, like the traditional gathering around a fireplace (iziko), serves as a social context where cultural values are transmitted and knowledge is constructed. The article establishes the importance of integrating Indigenous ways of knowing into education and research. It introduces the concept of CRST and proposes to conceptualize it using the cultural values of *Ubuntu* and *Eziko* as theoretical frameworks. It explores the concept of cultural production and how individuals are imbued with cultural values through processes of enculturation. Drawing parallels between the iziko and the science classroom, it argues that both settings serve as platforms for transmitting and maintaining cultural values, including IK values. Hence, as social actors, participants in both contexts are imbued with cultural values through enculturation, making them essential cultural production aspects.

The article argues that CRST can be understood as a form of cultural production wherein individuals acquire and generate scientific knowledge within the framework of their cultural backgrounds. It emphasizes the pivotal role of teachers as cultural mediators, akin to the role played around a fireplace, where participants are immersed in the values and activities around the iziko. Hence, cultural production is described as the process by which symbolic aspects of culture are shaped by the systems of production, distribution, and reception in which they are embedded. Drawing from Schmutz and Miller (2015), cultural production connotes "ways in which symbolic components of culture are influenced by the systems of production, distribution, and reception in which they are embedded" (p. 1). This process involves transmitting and perpetuating cultural forms and values through generational socialization. Just as participants around the fireplace are imbued with the values of their social milieu, learners

in science classrooms are imbued with the values of the scientific subculture prevalent within the educational setting. Through this cultural production, individuals develop a cultural identity shaped by their sociocultural backgrounds. Chen and Lin (2016) explained cultural identity as the "experience, enactment, and negotiation of dynamic social identifications by group members within particular settings" (p. 1). However, the spirit of interrelatedness, embodied in the concept of Ubuntu, ensures successful social interactions within these contexts, facilitating the effective transmission of cultural values and knowledge. Ubuntu, as a value of humanness, fosters meaningful interactions among participants within both the fireplace and science classroom settings, enabling them to collaboratively co-create knowledge and enhance the effectiveness of teaching and learning processes.

Cultural production encompasses various processes, including the acquisition and creation of scientific knowledge within the framework of an individual's sociocultural background. Invariably, IK and values specific to economic practices are essential for the well-being of communities. According to Sergon et al. (2022), there "exist[s] situated Indigenous economic knowledge, values that are significant in ensuring community's well-being" (p. 37). As a cultural acquisition, science is embedded within the subcultures of different societies. Therefore, science education can be viewed as cultural production within the broader societal matrix (Aikenhead & Lima, 2009; Ogunniyi, 2015; Dag, 2022). According to Aikenhead and Lima (2009), science teaching and learning are manifestations of sociocultural acquisition driven by values. Consequently, science classrooms and fireplaces serve as platforms for cultural production, maintenance, and transmission, contributing to the enculturation of individuals into the values of their respective cultures, including IK values, as noted by Jegede and Aikenhead (1999) and Ogunniyi (2015). This recognition underscores the cultural nature of scientific knowledge, highlighting the role of teachers who facilitate the transmission of cultural values within the classroom. In this respect, Jegede and Aikenhead (1999) stated that "teachers assume the role of cultural brokers in the classroom" (p. 46).

Science education (teaching and learning) serves as a mechanism for the cultural enculturation of learners into the norms and values of the scientific community, facilitated by their teachers. Therefore, science teaching must consider the culturally mediated scientific knowledge embedded within the sociocultural backgrounds of both teachers and learners. Additionally, there is a necessity for the development and utilization of culturally sensitive curricular materials and resources. The dynamics within the science classroom are influenced by the interactions between social actors, including teachers and learners, and how teaching is enacted through the curriculum. Similar to the communal warmth and comfort experienced around a fireplace, the science classroom serves as a space where learners can freely express their understandings, misunderstandings, and errors, expecting to receive guidance and support from the teacher. The teacher and learners' relationship in the science classroom parallels that of the facilitator and participants around the fireplace. Moreover, the iziko represents a microcosm of the broader sociocultural background, instilling individuals within its social

context with societal and cultural values. In this article, science classrooms are also viewed as microcosms within teachers' and learners' more extensive sociocultural backgrounds.

Furthermore, the concept of *Eziko* illustrates the array of activities occurring within the social settings of the iziko, analogous to those found in science classrooms. Eziko encompasses a range of interactions, engagements, arguments, and knowledge creation and validation, all facilitated by a "teacher" or more knowledgeable other (MKO) (Lave & Wenger, 1991), as observed in both the iziko and science classrooms. I contend that the convergence of values among social actors within these contexts drives the observed activities. By juxtaposing the activities of the iziko with those in the science classroom, the article underscores the commonality of values and interactions within social contexts. Understanding these cultural dynamics is crucial for effective CRST and teaching outcomes. Similar to the communal participation expected during the cooking (sipheka) and serving (sisophula) activities around the fireplace, learners in science classrooms are encouraged to engage actively during lessons. Drawing from the communal dynamics observed around the fireplace, where individuals participate in cooking and serving activities, I extend this analogy to the science classroom. I argue that the interactions and engagements within the classroom resemble the cooking process (sipheka), while the creation and validation of knowledge mirror the serving of food (sisophula). In both settings, teachers play a crucial role in guiding and enculturating learners into the culture of science. Just as elders facilitate interactions around the fireplace, teachers mediate the exchange of values within the classroom to foster meaningful learning outcomes.

This article advocates for the role of teachers as cultural brokers in facilitating CRST within educational settings. Drawing upon the ethos of Ubuntu, which emphasizes interconnectedness, empathy, and respect for diverse perspectives, the article argues that teachers must embody these principles to effectively engage with students from diverse cultural backgrounds. By enacting the spirit of Ubuntu, teachers can create inclusive learning environments where students feel valued, supported, and empowered to contribute their unique perspectives to the learning process. The article demonstrates how incorporating Ubuntu principles into teaching practices through examples and theoretical insights can enhance student learning outcomes and promote equity and social justice in education. Overall, the article underscores the importance of fostering a sense of community and mutual respect within classrooms to ensure culturally responsive teaching and meaningful educational experiences for all learners.

Implications and Future Directions: The article concludes by emphasizing the importance of considering the sociocultural worldviews of teachers and learners and the cultural context of the classroom in CRST. It proposes further research to explore the role of sociocultural backgrounds in shaping teaching practices and educational outcomes.

Scientific Perspective of the Fireplace: Additionally, the article briefly touches upon the scientific aspects of fire-making techniques, linking them to human history, epistemology, and ontology. This highlights the scientific acquisition embedded within cultural practices like those

observed around the fireplace. Overall, the article presents a holistic view of CRST that acknowledges the cultural nuances inherent in educational settings, particularly in South Africa. It underscores the importance of incorporating Indigenous cultural values into science education for more meaningful learning experiences.

Disclosure and Conflicts of Interest

There is no conflict of interest regarding the article.

REFERENCES

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269–287. https://doi.org/10.1002/(SICI)1098-2736(199903)36:3<269::AID-TEA3>3.0.CO;2-T

Aikenhead, G., & Lima, K. E. C. (2009). Science, culture, and citizenship: Cross-cultural science education. *Revista Brasileira De Pesquisa Em Educação Em Ciências, 9*(3), 1–15. https://periodicos.ufmg.br/index.php/rbpec/article/view/3998

Allchin, D. (1999). Values in science: An educational perspective. *Science & Education 8*, 1–12. https://doi.org/10.1023/A:1008600230536

Askeland, H. (2020). Values—Reviewing the construct and drawing implications for values work in organisation and leadership. In H. Askeland, G. Espedal, B. Jelstad Løvaas & S. Sirris (Eds.), Understanding values work (pp. 15–34). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-37748-9_2

Battiste, M., Bell, L., & Findlay, L. (2002). Decolonizing education in Canadian universities: An interdisciplinary, international, indigenous research project. *Canadian Journal of Native Education 26* (2), 82–95. https://doi.org/10.14288/cjne.v26i2.195923

Becker, L., & Jaakkola, E. (2020). Customer experience: Fundamental premises and implications for research. *Journal of the Academy of Marketing Science*. https://doi.org/10.1007/s11747-019-00718-x

Bonow, T., & Follette, W. (2009). Beyond values clarification: Addressing client values in clinical behavior analysis. *The Behavior Analyst, 32*, 69–84. https://doi.org/10.1007/BF03392176

Brown, J., Ring-Whalen, E., Roehrig, G., & Ellis, J. (2018). Advancing culturally responsive science education in secondary classrooms through an induction course. *International Journal of Designs for Learning, 9*(1), 14–33. https://doi.org/10.14434/ijdl.v9i1.23297

Brown, M., Altrichter, H., Shiyan, I., Rodríguez Conde, M. J., McNamara, G., Herzog-Punzenberger, B., Vorobyeva, I., Vangrando, V., Gardezi, S., O'Hara, J., Postlbauer, A., Milyaeva, D., Sergeevna, N., Fulterer, S., García, A. G., & Sánchez, L. (2022). Challenges and opportunities for culturally responsive leadership in schools: Evidence from four European countries. *Policy Futures in Education, 20*(5), 580-607. https://doi.org/10.1177/14782103211040909

Burnett, S., Ahmed, N., Matthews, T., Oliephant, J., & Walsh, A. (2023). A politics of reminding: Khoisan resurgence and environmental justice in South Africa's Sarah Baartman district. *Critical Discourse Studies, 20*(5), 524–539. https://doi.org/10.1080/17405904.2022.2092165

Chen, Y., & Lin, H. (2016). Cultural identities*. Oxford Research Encyclopaedia of Communication*. https://doi.org/10.1093/acrefore/9780190228613.013.20

Chigangaidze, R. K., Matanga, A. A., & Katsuro, T. R. (2022). Ubuntu philosophy as a humanistic-existential framework for the fight against the Covid-19 pandemic. *Journal of Humanistic Psychology, 62*(3), 319-333. https://doi.org/10.1177/00221678211044554

Coates, K., Trudgett, M., & Page, S. (2023). Indigenous institutional theory: A new theoretical framework and methodological tool. *Australian Educational Researcher, 50*, 903–920. https://doi.org/10.1007/s13384-022-00533-4

Dag, V. (2022). The politics of cultural production: Exile, integration, and homeland in Europe's Kurdish diaspora. *Diaspora Studies*, *15*(3), 271-296. https://doi.org/10.1163/09763457-bja10019

Department of Education (DoE). (2001). *The manifesto on values, education, and democracy*. https://www.gov.za/documents/manifesto-values-education-and-democracy

Department of Basic Education (DBE). (2011). *Curriculum and assessment policy statement (Grades 10–12): Life Sciences*. https://www.education.gov.za/LinkClick.aspx?fileticket=_yUNfV0A_8o%3D&tabid=570&portalid=0&mid=1558

Douglas, H. (2023). Science and values. In M. Gattinger (Eds.), *Democratizing risk governance*: *Bridging science, expertise, deliberation and public values* (pp. 55–77). Palgrave Macmillan. https://doi.org/10.1007/978-3-031-24271-7_3

Dube, F. (2020). The South African constitution as an instrument of doing what is just, right and fair. *In die Skriflig 54*(1), a2601. https://doi.org/10.4102/ids.v54i1.2601

Dube, F. 2023. Ubuntu: An underutilised foundational constitutional principle of South African environmental law. *Journal of Law, Society and Development*, 10. https://doi.org/10.25159/2520-9515/13512

Ewuoso, C., & Hall, S. (2019). Core aspects of Ubuntu: A systematic review. *The South African Journal of Bioethics and Law, 12*(2), 93–103. https://doi.org/10.7196/SAJBL.2019.v12i2.679

Foley, D. (2003). Indigenous epistemology and indigenous standpoint theory. *Social Alternatives, 22*(1), 44–52.

Frese, M. (2015). Cultural practices, norms, and values. *Journal of Cross-Cultural Psychology, 46*(10), 1327–1330. https://doi.org/10.1177/0022022115600267

Gamage, K., Dehideniya, D., & Ekanayake, Y. (2021). The role of personal values in learning approaches and student achievements. *Behavioural Science, 11*. https://doi.org/10.3390/bs11070102

Gay, G. (2018). *Culturally responsive teaching: Theory, research and practice*. Teachers College Press.

Giorgetti, F. M., Campbell, C., & Arslan, A. (2017). Culture and education: Looking back to culture through education. *Paedagogica Historica, 53*(1-2), 1–6. https://doi.org/10.1080/00309230.2017.1288752

Goduka, N. (2005). Eziko: Sipheka Sisophula, Nguni foundations for educating/researching for sustainable development. *South African Journal of Higher Education, 19*(3), 58–72. http://doi.org/10.4314/sajhe.v19i3.25504

Goduka, N., Madolo, Y., Rozani, C., Notsi, L., & Talen, V. (2013). Creating spaces for Eziko Sipheka Sisophula theoretical framework for teaching and researching in higher education: A philosophical exposition indilinga. *African Journal of Indigenous Knowledge Systems, 12*(1), 1–12.

Handayani, R. D., Wilujeng, I., & Prasetyo, Z. K. (2018). Elaborating Indigenous knowledge in the science curriculum for the cultural sustainability. *Journal of Teacher Education for Sustainability, 20*(2), 74–88. http://doi.org/10.2478/jtes-2018-0016

Hernandez, A., & Burrows, K. (2021). Implementing culturally relevant teaching in the classroom. *Open Journal of Leadership, 10*, 338–363. http://doi.org/10.4236/ojl.2021.104020

Herstein, L. (2022). Culture and science – science in culture: A relational approach to the cultural connectedness of science. In P. Bursztyka, E. Kramer, M. Rychter & R. Auxier (Eds.), *Philosophy of culture as theory, method, and way of life: Contemporary reflections and applications* (pp. 297–324). Brill. https://doi.org/10.1163/9789004515796_016

Hirschheim, R. (2008). Some guidelines for the critical reviewing of conceptual papers. *Journal of the Association for Information Systems, 9*(8), 432–441.

Humphrey, G., Gillson, L., & Ziervoge, G. (2021). How changing fire management policies affect fire seasonality and livelihoods. *Ambio, 50*, 475–491. https://doi.org/10.1007/s13280-020-01351-7

Ilmi, A. (2014). Rethinking development: An Indigenous African communal approach. *Counterpoints, 443*, 142–156.

Jegede, O., & Aikenhead, G. (1999). Transcending cultural borders: Implications for science teaching. *Journal for Science & Technology Education, 17*(1), 45–66. http://dx.doi.org/10.1080/0263514990170104

Jaakkola, E. (2020). Designing conceptual articles: Four approaches. *Academy of Marketing Science Rev*iew *(10),* 18–26. https://doi.org/10.1007/s13162-020-00161-0

Karlsson, A., Håkansson, M., Sjöblom, J., & Ström, H. (2020). Light my fire but don't choke on the smoke: Wellbeing and pollution from fireplace use in Sweden. *Energy Research and Social Science, 69*, 1–11. https://doi.org/10.1016/j.erss.2020.101696

Kelley, T. & Knowles, G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*, 11. https://doi.org/10.1186/s40594-016-0046-z

Khosrowjerdi, M., & Bornmann, L. (2021). Is culture related to strong science? An empirical investigation. *Journal of Informetrics, 15*. https://doi.org/10.1016/j.joi.2021.101160

Kluckhohn, C. (1951). Values and value-orientations in the theory of action: An exploration in definition and classification. In T. Parsons & E. Shils (Eds.), *Toward a General Theory of Action* (pp. 388–433). Harvard University Press, Cambridge. http://dx.doi.org/10.4159/harvard.9780674863507.c8

Kostrova, E. (2018). The "Ought"-dimension in value theory: The concept of the desirable in John Dewey's definition of value and its significance for the social sciences. In A. Christian, D. Hommen, N. Retzlaff & G. Schurz (Eds.), *Philosophy of Science: Between the natural sciences, the social sciences and the humanities* (pp. 171–186). Springer, Cham.

Kovach, M. (2009). *Indigenous methodologies: Characteristics, conversations, and contexts* (2nd ed.). University of Toronto Press.

Kovach, M. (2010). Conversation Method in Indigenous Research. *First Peoples Child & Family Review*, *5* (1), 40–48. https:// doi.org/10.7202/1069060ar.

Khathi, J., Ajani, O., & Govender, S. (2022). Exploring Teachers' Lived Experiences on the Integration of Values Education in South African High Schools. *Research in Social Sciences and Technology, 7(*2), 108-128. https://doi.org/10.46303/ressat.2022.12

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Marschall, S. (2019). Memory objects: Material objects and memories of home in the context of intra-African mobility. *Journal of Material Culture, 24*(3), 253–269. https://doi.org/10.1177/1359183519832630

Mathebula, M., & Martinez-Vargas, C. (2023). Ubuntu as a valued capability for university students in South Africa. *Journal of Student Affairs in Africa, 11*(2), 17–33. https://doi.org/10.24085/jsaa.v11i2.3624

Mhakure, D., & Otulaja, F. S. (2017). Culturally-responsive pedagogy in science education. In F. S. Otulaja, & M. B. Ogunniyi (Eds.), *The World of Science Education: Handbook of Research in Science Education in Sub-Saharan* (pp. 81–100). Sense Publishers, Rotterdam. https://doi.org/10.1007/978-94-6351-089-9_6

Mlondo, N. (2022). Umuntu Ngumuntu Ngabantu (a person is a person because of/or through others) and the notion of inclusive education. In M. O. Maguvhe & M. M. Masuku (Eds.), *Handbook of Research on Creating Spaces for African Epistemologies in the*

Inclusive Education Discourse (pp. 1-13). IGI Global. DOI: 10.4018/978-1-6684-4436-8.ch001

Molefe, M. (2016). African ethics and partiality. *Phronimon, 17*, 1–19. https://doi.org/10.17159/2413-3086/2016/142

Moreton-Robinson, A., & Walter, M. (2009). Indigenous methodologies in social research. In M. Walter (Eds.), *Social research methods* (pp. 1–18). Oxford University Press.

Mthimkhulu, S. (2024). Ubuntugogy as a Viable Pedagogical Construct in African Education: A Literature Review. *Journal of Culture and Values in Education, 7*(1), 83-98. https://doi.org/10.46303/jcve.2024.6

Mugumbate, J. R. (2020). Samkange's theory of Ubuntu and its contribution to a decolonised social work pedagogy. In C. Morley, P. Ablett, C. Noble & S. Cowden (Eds.), *Routledge Handbook of Critical Pedagogies for Social Work* (pp. 141–160). Routledge.

Mugumbate J., & Nyanguru A. (2013). Exploring African philosophy: The value of Ubuntu in social work. *African Journal of Social Work*, *3*(1), 82–100.

Mugumbate, J. R., Mupedziswa, R., Twikirize, J. M., Mthethwa, E., Desta, A. A., & Oyinlola, O. (2023). Understanding Ubuntu and its contribution to social work education in Africa and other regions of the world. *Social Work Education, 43*(4), 1123–1139. https://doi.org/10.1080/02615479.2023.2168638

Nakata, M. (2007). *Disciplining the savages, savaging the disciplines*. Aboriginal Studies Press.

Ndiangui, P., Zhang, J., Ozfidan, B., & Halpern, C. (2024). Navigating Cross-Cultural Challenges: A Phenomenological Study on Strategies for International Faculty in Higher Education to Support Local Students. *Journal of Culture and Values in Education, 7*(2), 284-297. https://doi.org/10.46303/jcve.2024.24

Nkambule, B. (2023). The Perceived Heads of Departments' Infusion of Ubuntu Values in Curriculum and Knowledge Sharing Leadership in Under-Resourced Public Schools. *Journal Of Curriculum Studies Research, 5*(2), 186-205. https://doi.org/10.46303/jcsr.2023.26

Ogunniyi, M. B. (2015). The educational and cultural values of IKS in modern city. In M. B. Ogunniyi & K. R. Langenhoven (Eds.), *The Relevance of Indigenous Knowledge to African Socioeconomic Development in the 21st Century*. Proceedings of the inaugural conference of African Association for the Study of Indigenous Knowledge Systems (pp. 102-113). Windhoek, Namibia.

Ogunniyi, M.B. (2020). Tapping the potential of Ubuntu for a science that promotes social justice and moral responsibility. In H. A. Yacoubian & L. Hansson (Eds.), *Nature of Science for Social Justice. Science: Philosophy, History and Education* (pp. 157–176). Springer, Cham. https://doi.org/10.1007/978-3-030-47260-3_9

Østergaard, E. (2017). Earth at Rest. *Science & Education, 26*, 557–582. https://doi.org/10.1007/s11191-017-9906-2

Panayotova, P. (2023). Scientific values and the value of science. *Science & Education*. https://doi.org/10.1007/s11191-023-00461-4

Parsons, E.C., & Carlone, H.B. (2013). Culture and science education in the 21st century: Extending and making the cultural box more inclusive. *Journal of Research in Science Teaching, 50*(1), 1-11. http://dx.doi.org/10.1002/tea.21068

Piñar, G., & Sterflinger, K. (2021). Natural sciences at the service of art and cultural heritage: An interdisciplinary area in development and important challenges. *Microbial Biotechnology, 3*, 806–809. http://doi:10.1111/1751-7915.13766

Raeff, C., Fasoli, A., Reddy, V., & Mascolo, M. (2020). The concept of culture: Introduction to spotlight series on conceptualizing culture. *Applied Developmental Science, 24*(4), 295–298. https://doi.org/10.1080/10888691.2020.1789344

Roccas, S., & Sagiv, L. (2017). *Values and behavior: Taking a cross cultural perspective* (1st ed.). Springer International Publishing. https://doi.org/10.1007/978-3-319-56352-7

Samuels, A. (2008). Exploring Culturally Responsive Pedagogy: Teachers' perspectives on fostering equitable and inclusive classrooms. *SRATE Journal, 27*(1), 22–30.

Schmutz, V., & Miller, C. (2015). Production of Culture. In R. Scott & S. Kosslyn (Eds.), *Emerging Trends in the Social and Behavioral Sciences* (pp.1–14). John Willey. https://doi.org/10.1002/9781118900772.etrds0265

Schwartz, S. H. (2012). An overview of the Schwartz Theory of basic values. *Online Readings in Psychology and Culture, 2*(1), 1–20. https://doi.org/10.9707/2307-0919.1116

Seewann, L., & Verwiebe, R. (2020). How do people interpret the value concept? Development and evaluation of the value conceptualisation scale using a mixed method approach. *Journal of Beliefs & Values, 41*(4), 419–432. http://doi.org/10.1080/13617672.2019.1707748

Sergon, P. J., Akoth, S. O., & Dzinekou, J. Y. (2022). The role of Indigenous knowledge: practices and values in promoting socio-economic well-being and equity among Endorois community of Kenya. *AlterNative: An International Journal of Indigenous Peoples, 18*(1), 37-45. https://doi.org/10.1177/11771801221086724

Skimina, E., Cieciuch, J., Schwartz, S. H., Davidov, E., & Algesheimer, R. (2019). Behavioral signatures of values in everyday behavior in retrospective and real-time self-reports. *Frontiers in Psychology, 10*, Article 281. https://doi.org/10.3389/fpsyg.2019.00281

Sorensen, C. (2019). The uncertain origins of fire-making by humans: The state of the art and smouldering questions. *Mitteilungen der Gesellschaft für Urgeschichte, 28*, 11–50.

Thomas, M., & Tripp, L. (2020). The impact of culturally responsive teaching on underrepresented student's persistence in STEM: Culturally responsive instructional strategies. In L. Tripp & R. M. Collier (Eds.), *Culturally responsive teaching and learning in higher education* (pp. 164–192). IGI Global. https://doi.org/10.4018/978-1-5225-9989-0

Tuck, E., & Yang, K. (2012). Decolonization is not a metaphor. *Decolonization: Indigeneity, Education & Society,* 1 (1), 1–40. https://doi.org/10.25058/20112742.n38.04.

Upadhyay, B. R. (2005). Using students' lived experiences in an urban science classroom: An elementary school teacher's thinking. *Science Education, 90*(1), 94–110. https://doi.org/10.1002/sce.20095

Van Breda, A. (2019). Developing the notion of Ubuntu as African theory for social work practice. *Social Work/Maatskaplike Werk, 55*(6), 439–450. http://doi.org/10.15270/52-2-762

Verbuyst, R. (2022). *Khoisan Consciousness: An ethnography of emic histories and indigenous revivalism in post-apartheid Cape Town*. Brill.

Wallace, J., Howes, E., Funk, A., Krepski, S., Pincus, M., Sylvester, S., Tsoi, K., Tully, C., Sharif, R., & Swift, S. (2022). Stories that teachers tell: Exploring culturally responsive science teaching. *Education Science, 12*(6), 401. https://doi.org/10.3390/educsci12060401

Yeseraw, A., Melesse, T., & Kelkay, A. D. (2023). Inclusion of Indigenous knowledge in the new primary and middle school curriculum of Ethiopia. *Cogent Education, 10*(1), 1–23. https://doi.org/10.1080/2331186X.2023.2173884

Zidny, R., Sjöström, J., & Eilks, I. A. (2020). Multi-perspective reflection on how Indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education, 29*, 145–185. https://doi.org/10.1007/s11191-019-00100-x

APPENDİX

Table 1.

Conceptualizing CRST in science classrooms using the values of Ubuntu and Eziko (and their elements) as Indigenous frameworks

	Domain theories and their key components/concepts	Perspectives of analysis in relation to key concepts to be analyzed or used to analyze in terms of analysis of the domain theories and their key components/concepts	Translating the target phenomenon into conceptual language and integrating the components or concepts with argumentation
1	*Eziko*	*Eziko: Sipheka Sisophula* or *eZiko* for short (Goduka, 2005). A values-driven scientific endeavor, including IK, which provides for CRST. Goduka (2005) used "*Eziko* to indicate interactive/participatory learning/research processes and practices around which to engage participants in the activities of sipheka (we cook), sisophula (and dish out)" (p. 59). This encompasses the entirety of the processes and activities which take place in and around the iziko and in which participants engage. Engagement fosters a "spirit of connectedness, humility, and respect that affirm diverse stories participants bring, and validate new knowledge they co-create" through, for example, activities such as discussions (*iimbizo*) folktale, dancing, singing, storytelling, etc., while cooking and dishing of cooked food are performed.	This is values-driven classroom science (including IK) teaching. The totality of activities that happen within the science classroom or practices within the science classroom that promote teaching and learning engagements between learners and teachers and among learners. E.g., discussions, role-playing, debates, quizzes, group work, calculating, practical work, presenting, listening for information, watching videos, etc. Through these activities, learners participate and have meaningful conversations among themselves and with their teacher to share and co-construct knowledge.
2	*Iziko*	Fireplace or space – usually 'natural' open space with free wind within the social context where the Indigenous people live. During the daytime, the sun is a veritable light source, while trees, under which the fire is made, provide shade for the participants. At night, the moon usually offers a good source of light. However, in the absence of the moon, the fire provides lighting. The fire made for cooking is also a veritable source of lighting.	Science classroom – the social context where teaching and learning activities take place. Such spaces are characterized by good lighting generated through electricity or provided by sunlight. Ventilation may also be ensured through air conditioning or fresh air from the surrounding environment where the classroom is situated. The classroom may be surrounded by nature, plants, and greenery (e.g., trees, shrubs, and grass) and lighted by the sun. The inner walls of the classroom can also be decorated with photos of nature.
3	Sipheka	'We cook' relates to the cooking process, which encompasses how the food is cooked. Individuals within that sociocultural context are inculcated with the 'science' of cooking during the process. Fundamentally, there is an 'Elderly' or 'Chief Chef' who facilitates the cooking process through laid-down procedures (Unwritten curriculum) passed from one generation to another. There may also be other 'mature' but still 'Amateur Chef' who have gone through the cooking process rituals or training. The resources required for cooking include the food material to be cooked, cooking utensils, stone structure on which utensils are situated (usually a 3-rock structure), sticks/wood to make fire, lighter to spark fire, etc. The cooking process involves pre-, real-time- and post-cooking phases during which participants play vital roles. Pre-	The 'cooking' process in the science classroom revolves around how knowledge (food) is constructed and gained through enculturating learners into the culture of science. This is embedded in the science classroom's teaching (and learning) activities. As the activator of teaching (and learning), the teacher facilitates the process while guided by the curriculum. There may also be more 'intelligent' learners who can teach their colleagues. Academic resources include textbooks, writing materials, calculators, resources for practicals, etc. The teaching process includes pre-, real-time, and post-teaching activities. For pre-teaching, the teacher prepares, for example, through lesson plans, notes, setting the laboratory, preparing relevant videos, charts, etc. The teacher uses the resources gathered during pre-teaching to engage with learners for real-time teaching. This facilitates teacher-learner engagement for co-creating knowledge and understanding. Engagement may involve discussions, role-playing, debate, quizzes, group work, etc.

		cooking activities may include washing, cutting, peeling, grating, etc., raw food, while real-time cooking activities may include turning/stirring the cooked food, adding ingredients, fanning ignited wood to maintain the fire, etc. During real-time cooking, participants may engage in folktales, dancing, singing, storytelling, etc. The post-cook roles may involve putting off the fire, preserving incompletely burnt wood, dishing cooked food, washing the plates, etc.	Conceptualizing subject-specific classroom CRST in terms of how they relate with components or concepts of the theories is enunciated below: Physics: *Fire making – Friction occurs when two stones or sticks are struck together to make fire. *Energy transfer (conduction) - Utensils used as good conductors of heat; *Heat production – Fire produces heat for cooking; *Balance of forces replicated in the 3-rock structure; *State of matter – solid, liquid, and gas. Chemistry: *Breaking of bonds – Foods as chemicals whose bonds are broken when heat is applied; *Endothermic and exothermic reactions related to heat; *Temperature pertaining to heat. Biology: *Types of food cooked – Protein, carbohydrates, fats; *Warmth – (Body heat) – thermoregulation, homeostasis, and metabolism.
4	*Sisophula*	'We dish' – This connotes what happens after the food is cooked. After that, the food is ready to be dished out to participants around the fireplace. Each gets their plates where the food is dished in, or the food is dished on a large plate from where everyone feeds. Each participant is served rations intended to satisfy their appetite. Plausibly, each participant has different appetite and hunger rates.	Learning and understanding (achieving teaching and learning outcomes) that may lead to achievement behaviors.
5	Ubuntu	Denotes interdependence or inherent interconnectedness among people.	In science classrooms, there exists an interconnectedness between 'teachers' and 'learners' as well as among the learners. Though the teacher facilitates teaching and learning, they are co-creators of knowledge with learners. Compared with what is obtained around the fireplace, the interconnectedness within science classrooms results from the intersection of values brought into the classroom by teachers, learners, and those inherent in the curriculum.