Challenging the Hegemony of Western Science via Culturally Relevant Science Teaching

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Abstract

Western science has dominated global knowledge production in science leading to suppression and marginalization of non-Western knowledge systems—the indigenous knowledge. Science teaching places less emphasis on indigenous knowledge and unintentionally privileges Western science. Culturally relevant science teaching (CRST) seeks to disrupt this hegemony by recognizing and valuing diverse knowledge systems and ways of knowing. Drawing on Critical Theory as a research framework, the study explores the historical context of Western science, the comprehensive examination of CRST, and its potential benefits and challenges. The methodology involves qualitative document analysis, examining historical documents, scientific writings, and educational policies related to Western science hegemony and CRST. Results highlight the limitations of Western science and the empowering potential of CRST for marginalized communities. Challenges in implementation, including teacher training and resource availability, are acknowledged. Thus, the study recommends institutionalizing CRST in science education, integrating CRST in science education curricula, and providing teacher training.

Keyword:

Culturally Relevant Science Teaching (CRST), hegemony, science education, traditional science, Western science.

Introduction

Science is a human construct that progressed from the “early speculations about the natural world” (Melville et al., 2022, p. 705). It is a human endeavor, as people have a variety of ways of making sense of nature (Klopfer & Aikenhead, 2022). This humanistic aspect of science was introduced by Ogawa (1995). However, there are also notions of it as “acultural” (Mathis et al., 2023; Medin & Bang, 2014). Scientists try to eliminate biases in knowledge formation by achieving objective results from experimental methods (Mathis et al., 2023). This means science is “constrained only by the objective nature of reality” (Medin & Bang, 2014, p. 18).

The problem is that powerful culture-insensitive science education displaces traditional ways of knowing, being, and valuing, resulting in the erosion and loss of integrity of knowledge systems and practices of minority groups, such as Indigenous Peoples (IPs) (Taylor & Cobern, 1998). The debate on the universality of science continues due to the growing recognition of the importance of indigenous science in the educational arena (Iaccarino, 2003). Mainstream education offers scientific knowledge based on the

Western model of science. This is especially true in developing countries where science is taught based on Western concepts and culture (Iaccarino, 2003). Teachers unintentionally privileged and reinforced hegemonic principles, eurocentric knowledge, and ways of knowing (Aikenhead, 2001; Boutte, Kelly-Jackson, & Johnson, 2010; Robles-Pineros *et al*., 2020). In higher education institutions, indigenous knowledge is recognized only if understood and validated in Western terms and/or separated from the spiritual and cultural context (Morgan, 2003).

Western science was thought to be the only provider of absolute, universal, and valid scientific knowledge (Aikenhead, 2001; Baptista & Molina-Andrade, 2021; Brayboy & Castagno, 2008; Melville et al., 2022) and does not recognize culture. This should not be the case as Westerners used indigenous knowledge and resources to build their science and survive (Morgan, 2003). Therefore, Western science should also be considered indigenous or cultural (Aikenhead, 2001).

While Aikenhead (2001) argues that Western science should be considered indigenous or cultural, Morgan (2003) highlights that Western science's realities often contradict indigenous science's realities (Morgan, 2003) and traditional knowledge. Although some indigenous knowledge is incorporated in the science taught at schools, such as herbal medicine, these are taught using the terms and realities of the Western countries (Morgan, 2003). What is alarming is that these terms are considered unique and have no equivalent terms in other cultures. These beliefs on indigenous knowledge usually result in rote memorization of concepts rather than meaningful learning.

The hegemony of Western science has historically excluded non-Western knowledge systems from mainstream science education (Aikenhead, 2001), leading to a narrow and incomplete understanding of the world (Baptista & Molina-Andrade, 2021) and issues on social power and privilege (Aikenhead, 2001). For example, Wan Chen (1313) in China first developed the steam engine, but it was James Watson (1776) who was known for it (Medin & Bang, 2014; Teresi, 2003). India has greatly contributed to developing a scientific method, but Bacon was recognized (Medin & Bang, 2014). If the hegemony is not challenged, it will continue to normalize scientific knowledge of Western culture and disadvantage other cultures' knowledge systems (Aikenhead, 2001; Mazzocchi, 2006; Melville et al., 2022).

Culturally Relevant Science Teaching (CRST) offers a promising approach to science education that challenges Western science hegemony by recognizing and valuing diverse cultural perspectives and knowledge systems (Jones & Donaldson, 2021; Mckinley, Brayboy, & Castagno, 2008; Robles-Pineros et al., 2020). Mckinley, Brayboy, and Castagno (2008) argued that indigenous knowledge is important and relevant to contemporary science. By critically examining biases and assumptions about science and culture and incorporating CRST into science education, a more inclusive and comprehensive understanding of science, improved student engagement, academic achievement, and interest in science, particularly among underrepresented groups (Kolovou, 2022), will be promoted.

This paper addresses the call to challenge the hegemony of Western Science in science education. It argues that indigenous or traditional knowledge and practices should not be dismissed as indigenous groups, especially in remote areas, still observe these knowledge and practices. These have worked for them until now. Thus, they need empowerment instead of being made inferior, which could be addressed through CRST. This paper aims to comprehensively examine CRST and discuss its implications for future practice and research in this area. It explores the historical context of Western science hegemony and the exclusion of non-Western knowledge systems from mainstream science education. It will also critically evaluate the potential benefits of CRST in science education, how it is implemented in the classroom, and the challenges it faces.

Critical Theory

Critical theory is a powerful lens for understanding educational disparities and injustices and transforming the structures perpetuating non-Western perspectives' marginalization (Smith, Avraamidou, & Adams, 2022; Strunk & Betties, 2019). It is a research framework with roots in the humanities and social sciences, specifically in the Frankfurt School (Allen-Brown & Nichols, 2004; Rexhepi & Torres, 2011). It seeks to investigate and challenge existing societal structures, power relations, and forms of oppression (Allen-

Brown & Nichols, 2004; Peca, 2000; Rexhepi & Torres, 2011). By relying on objective and subjective knowledge (Peca, 2000), critical theory challenges the concept of pure reason (Allen-Brown & Nichols, 2004). It shows that ideologies can be changed depending on the culture, history, and power (Allen-Brown & Nichols, 2004).

When applied to the context of education, critical theory attempts to understand how dominant ideologies are incorporated into the curricula, allowing hegemony to occur (Mayo, 2007; Smith, Avraamidou, & Adams, 2022; Strunk & Betties, 2019). Critical theorists and researchers often try to examine how power or knowledge is reproduced or interrupted (Strunk & Betties, 2019). Thus, critical theory helps provide a voice for groups who have been oppressed (Mayo, 2007; Smith, Avraamidou, & Adams, 2022) and is a powerful tool for dismantling hegemony in science education (Smith, Avraamidou, & Adams, 2022).

Critical theory contributes to the broader goal of creating an education system that enables diverse knowledge systems to be recognized and valued. It reveals how some knowledge systems are valued more highly, resulting in a more complex comprehension of systemic biases (Strunk & Betties, 2019). It aims to empower marginalized voices and knowledge traditions (Peca, 2000) by exploring ways to uplift non-Western perspectives. It also contributes to deconstructing biased educational paradigms in science (Smith, Avraamidou, & Adams, 2022) by challenging existing educational structures. It encourages open and critical discourse to create spaces that bridge different cultural and knowledge contexts (Strunk & Betties, 2019).

This paper used critical theory to frame an educational paradigm, the CRST, that challenges the hegemony of Western science in science education. It provides a strong research framework that may be used to comprehend and address the difficulties involved in recognizing and valuing diverse knowledge systems by critically examining power structures, unveiling hegemonic narratives, and advocating transformative action.

Methodology

This paper utilized qualitative document analysis. Document analysis is the procedure for reviewing and evaluating printed and electronic documents (Bowen, 2009). According to Bowen (2009), the procedure entails "finding, selecting, appraising (making sense of), and synthesizing data contained in documents" and categorizing it into themes. Content analysis is usually used in document analysis to categorize data. In this methodology, the following process was adapted from Altheide's 'Process of Document Analysis' (Altheide, 2000): (a) setting inclusion criteria for documents; (b) collecting documents; (c) articulating key areas of analysis; (d) document coding; (e) verification; and (f) analysis.

Table 1 shows the overview of the literature search for documents included in this study. These are historical documents, scientific writings, and educational policies that discuss different periods, specifically the Middle Ages to present, to trace the evolution of Western science and its intersections with power structures and articles, reports, or empirical documents on CRST. Documents were collected from the public domain. These documents were evaluated based on their relevance to the topic and objectives through initial reading.

There were three areas or themes considered in analyzing the documents. One is the historical context of Western science hegemony in mainstream science education and the exclusion of non-Western knowledge systems from mainstream science education. Second is the comprehensive examination of CRST and how it challenges the hegemony of Western science in science education. Third, the potential benefits of CRST in science education how it is implemented in the classroom, and the challenges it faces. Each document was manually coded and annotated to highlight relevant passages and patterns according to the identified themes.

Various documents were taken from credible sources and/or indexed in the Web of Science (WoS), Scopus, and ASEAN Citation Index to ensure validity and reliability. However, since only a few research on CRST was conducted, especially in the Philippines, documents were taken from Google Scholar, Open Journal Systems (OJS), conference proceedings, and press releases. Both authors reviewed the patterns or themes that emerged across different documents. The patterns or themes that emerged to ensure consistency and transparency.

Table 1

Overview of Literature Search

Keywords/topic	Sources	Identified articles and book chapter
Western Science (focusing on the hegemony of Western Science and its roots)	• Web of Science • Additional literature from Google Scholar, Open Journal Systems, Encyclopedia, Books, and Press	Aikenhead (2001); Aikenhead & Huntley (1999); Baptista & Molina-Andrade (2021); Hessen (2009); Iaccarino (2003); Kind & Osborne (2016); Klopfer & Aikenhead (2022); Mazzocchi (2006); Medin & Bang (2014); Melville *et al.* (2022); Nowell *et al.* (2023); Pickering (1992); Smith (2022); Teresi (2003); Zidny *et al.* (2020)
Indigenous/native/aboriginal science and knowledge	• Scopus • Web of Science • Additional literature from Google Scholar, Open Journal Systems, Books, Conference proceedings	Banes & Dela Cruz (2021); Baquete, Mutimucuio, & Grayson (2017); Brayboy & Castagno (2008); Cajete (2000); Donato-Kinomis (2016); Handayani *et al.* (2019); Mckinley, Brayboy, & Castagno (2008); Morgan (2003); Robles-Pineros *et al.* (2020)
Indigenous/native education	• Web of Science • Additional literature from the Conference proceeding	Cornelio & de Castro (2016); Deyhle & Swisher (1997); ECIP (2007)
Culturally relevant pedagogy (focusing on science education) or culturally relevant science teaching	• Scopus • Web of Science • Additional literature from Google Scholar, Open Journal Systems, Books, the Conference Proceedings	Abrams, Taylor, & Guo (2013); Aikenhead (2002); Boutte, Kelly-Jackson, & Johnson, (2010); Brown *et al.* (2019); Byrd (2016); Jones & Donaldson (2021); Kelly-Jackson & Jackson (2011); Kolovou (2022); Ladson-Billings (1995); Laughter & Adams (2012); Madkins & McKinney de Royston (2019); Mathis *et al.* (2023); Mensah (2011); Moll *et al.* (1992); Neri, Lozano, & Gomez (2019); Ogawa (1995); Pejaner & Mistades (2020); Smith, Avraamidou, & Adams (2022); Taylor & Cobern (1998); Young (2010)

A comprehensive process of identifying themes follows. Connections between documents were examined to extract meaningful insights and interpretations of the content. Findings were connected to the objectives, and implications were drawn based on the resulting patterns or themes (Table 2).

Table 2

Sample coding and abstraction

Sources	Sample phrases/codes	Categories	Themes
Aikenhead (2001); Aikenhead & Huntley (1999); Baptista & Molina-Andrade (2021); Hessen (2009); Iaccarino (2003); Kind & Osborne (2016); Klopfer & Aikenhead (2022); Mazzocchi (2006); Medin & Bang (2014); Melville *et al.* (2022); Nowell *et al.* (2023); Pickering (1992); Smith (2022); Teresi (2003); Zidny *et al.* (2020); Banes & Dela Cruz (2021); Baquete, Mutimucuio, & Grayson (2017); Brayboy & Castagno (2008); Cajete (2000); Donato-Kinomis (2016); Handayani et al. (2019); Mckinley, Brayboy, & Castagno (2008); Morgan (2003); Robles-Pineros et al. (2020)	Historical context of Western science hegemony, colonialism, imperialism, exclusion of non-Western knowledge systems	Development of Western science, Influence of feudalism, Spread through colonization	Understanding the roots of Western science hegemony
	Limitations in addressing environmental crises, social inequalities, decontextualization	Decontextualized science curricula, Failure to recognize different forms of reasoning, Translation challenges	Recognizing the limitations of Western science
Abrams, Taylor, & Guo (2013); Aikenhead (2002); Boutte, Kelly-Jackson, & Johnson, (2010); Brown *et al.* (2019); Byrd (2016); Jones & Donaldson (2021); Kelly-Jackson & Jackson (2011); Kolovou (2022); Ladson-Billings (1995); Laughter & Adams (2012); Madkins & McKinney de Royston (2019); Mathis *et al.* (2023); Mensah (2011); Moll *et al.* (1992); Neri, Lozano, & Gomez (2019); Ogawa (1995); Pejaner & Mistades (2020); Smith, Avraamidou, & Adams (2022); Taylor & Cobern (1998); Young (2010); Cornelio & de Castro (2016); Deyhle & Swisher (1997); ECIP (2007)	CRP as the foundation, CRST components, Incorporation of cultural backgrounds	Empowering underrepresented groups, Focusing on cultural backgrounds, Making science education accessible	Recognizing the importance of culture in science education
	Transforming science education, Challenging Western science hegemony, Empowering marginalized communities	Introducing diverse viewpoints, Documenting IKSP, Enhancing the educational process	Broadening scientific understanding through CRST
	Teacher resistance, Lack of training, Limited resources, Sociopolitical consciousness, Institutional norms	Teacher challenges, Need for training and support, Lack of resources, Sociopolitical consciousness, Institutional barriers	Challenges in CRST implementation

Results and Discussion

Western Science, Feudalism, and Colonization

Researchers of various research articles have dexterously addressed the historical context of Western science hegemony and the exclusion of non-Western knowledge systems from mainstream science education. They provide a comprehensive analysis of the development of Western science, influenced by colonialism and imperialism, which solidified its dominance and marginalized traditional knowledge systems. This is specifically true during colonial encounters where Western scientific frameworks are imposed, which causes students from non-Western cultural backgrounds to feel alienated and disengaged from science education. Initiatives towards inclusion and decolonization are emphasized, including incorporating non-Western knowledge systems into the curriculum, engaging with local communities and indigenous knowledge holders, and promoting cultural diversity in science classrooms.

Researchers also highlight the need for continued research and action to address the historical exclusion and promote a more inclusive and decolonized approach to science education. According to Brown *et al.* (2019), given "the small number of studies on cultural relevancy in STEM teacher education, research must consider how to draw connections between the interdisciplinary field of STEM education to educate teachers to bridge the theory-to-practice divide" (p. 4). In addition, Abrams, Taylor, and Guo (2013) highlighted that "many science education researchers have called for culturally responsive curricula to be taught in science classrooms with significant populations of indigenous learners" (p. 2).

Western science evolved from a Euro-American setting (Aikenhead, 2001; Pickering, 1992). The science and culture in the West became "intertwined and interdependent" (Melville et al., 2022, p. 706). It developed and gained dominance during the Renaissance, a revival of classical Greek and Roman learning, and a shift towards empirical observation and experimentation (Iaccarino, 2003; Mazzocchi, 2006). Yet, Western science was built upon the knowledge of Islamic civilization (Iaccarino, 2003). It was the Scientific Revolution of the 17th century, marked by the work of scientists such as Galileo, Kepler, and Newton, that solidified the principles of the scientific method and established a new approach to understanding the natural world based on observation, experimentation, and mathematical analysis (Hessen, 2009; Iaccarino, 2003).

The hegemony of Western science has its roots in feudalism. Medieval universities established in the Middle Ages were considered scientific centers and strong believers of feudal traditions (Hessen, 2009). During this period (from the 15th to 17th century), newly discovered scientific concepts were not recognized if they were not based on Aristotle's findings. Even natural sciences were prohibited at some point. Additionally, scientists such as Descartes, who came out against them, were condemned by the church and government (Hessen, 2009).

The expansion of European colonialism and imperialism played a significant role in the spread of Western science and feudalism. The Catholic church was considered the international center of feudalism. When colonization of non-Western countries heightened in the 16th century (Nowell, Webster, & Magdoff, 2023), Western science hegemony spread along with Catholicism (Hessen, 2009). The church used medieval universities as a powerful weapon to spread feudal tradition and hegemony (Hessen, 2009), as the colonial enterprise involved the imposition of European values, institutions, and knowledge systems.

European colonial powers viewed themselves as superior to the colonized peoples, including their knowledge systems, which were dismissed as primitive, superstitious, and backward (Iaccarino, 2003). This attitude was reflected in classifying knowledge into a hierarchy of sciences, with Western science at the top and non-Western knowledge systems at the bottom. This often involved the deliberate erasure of indigenous languages, cultural practices, and ways of knowing and the imposition of Western education systems that privileged European languages and cultures (Smith, 2022).

The legacy of colonialism and Western science hegemony continues to shape science education today. Science curricula are now focused on "abstract categories, laws, theories, models, and calculations" (p. 491), which are mostly decontextualized from learners' perspectives (Klopfer & Aikenhead, 2022).

Limits of Western Science

Research has shown that Western science has limitations in addressing certain issues, such as environmental crises and social inequalities. Non-Western knowledge systems offer alternative perspectives and solutions to these issues, but they have been historically excluded from mainstream science education. Iaccarino (2023) exemplified that:

> In developing countries, science education is based on Western concepts and culture, and it is taught by those for whom science is often unrelated to their culture. This leads students to deny the validity and authority of the knowledge transmitted to them by their parents and grandparents and creates tension in several societies. Even in developed countries, general education is a recent trend. (p. 222)

When students are encouraged to understand their culture while raising awareness of discrimination or inequality, they find learning relevant and meaningful (Byrd, 2016; Zidny et al., 2020). According to Zidny et al. (2020), it "has the potential to facilitate learners to make own sense of their world and reinforces their existing interpretation of natural phenomena" (p. 160).

The second limitation of Western science is its inability to recognize that there are different forms of reasoning based on one's culture (Kind & Osborne, 2016). Even science curricula today are decontextualized (Klopfer & Aikenhead, 2022). It fails to see how essential it is to answer causal questions on the nature of the world from different perspectives as it solely focuses on the experimental or scientific method (Medin & Bang, 2014). It also fails to consider the plurality of ways of knowing of each culture (Klopfer & Aikenhead, 2022). According to Medin and Bang (2014), a culture is said to practice science if an experience validates deductions made from one's particular social activity and "models of the world are reflexively adjusted to conform to observed regularities in the course of events" (p. 24). Furthermore, if scientific methods are taken from different perspectives, there might be different insights into the natural world (Medin & Bang, 2014) or similar findings. For instance, Nasir al-Din al-Tusi (1201-1274) and Nicolaus Copernicus (1473-1543) lived centuries apart and of different ways of understanding phenomena. However, both arrived at the same math, suggesting that the sun is the center of the universe (Teresi, 2003). This and other lost discoveries of non-Western countries were not popularized because only Western scientists were privileged (Teresi, 2003).

Another limitation of integrating Western science is translating terminologies from one language to another (Aikenhead, 2001). As Western science uses English as its language, it is somehow difficult for teachers from non-Western countries to define and translate it into their language. This is important as using simple words easily understood by the students is important in teaching science (Pejaner & Mistades, 2020). Aikenhead (2001) also noted that:

> Another source of conflict arises during the integration of Western and Aboriginal sciences when we translate from one language to another. With the aid of a dictionary or knowledgeable friend, we can translate an English word into, for instance, a Cree word. But we must be mindful that the thing we are actually referring to can change dramatically from one context to the next (p. 10)

If teachers fail to translate or define science terms correctly, this might dramatically change meaning from one context to another (Aikenhead, 2001). Eventually, important concepts embedded in the terms get lost in the translation.

Culturally Relevant Science Teaching (CRST)

The prevalence of discrimination, the belief that Western Science is the only true knowledge, and the struggles of minorities (especially the indigenous groups) at schools were some of the reasons why culturally relevant pedagogy (CRP) was conceptualized (Abrams, Taylor, & Guo, 2013; Ladson-Billings, 1995). CRP aims to empower underrepresented groups of students (Ladson-Billings, 1995). According to Ladson-Billings (1995), CRP is defined as "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes." Culturally relevant science teaching (CRST) builds on this idea by focusing on science education. Thus, CRP serves as the foundation of CRST (Laughter & Adams, 2012).

Culturally Relevant Science Teaching (CRST) is an approach to science education that recognizes students' cultural backgrounds and experiences and uses them as a basis for teaching science (Pejaner & Mistades, 2020). CRST seeks to make science education more accessible and relevant to students from diverse backgrounds by incorporating their cultural experiences, values, and perspectives into the curriculum (Jones & Donaldson, 2021). It has three criteria or components for students to learn meaningfully – academic success, cultural competence, and critical consciousness (Ladson-Billings, 1995).

In CRST, science is taught as a part of the students' broader cultural context. This approach recognizes that indigenous knowledge is not inferior compared to the science taught at schools (Kelly-Jackson & Jackson, 2011; Laughter & Adams, 2012). It emphasizes that science is deep-rooted in culture (Iaccarino, 2003; Pejaner & Mistades, 2020). In the article of Iaccarino (2003), he stressed that "although the language of science is often specialized, and thus inaccessible to non-specialists, science and culture are not different entities: science is part of culture, and how science is done largely depends on the culture in which it is practiced" (p. 221). This means that each indigenous group holds its concept of science (thus, indigenous science) based on its traditional knowledge system, beliefs, and practices.

CRST involves the integration of culturally relevant content and pedagogical practices into science teaching. Some studies have focused on using CRST, such as incorporating indigenous knowledge systems and practices (IKSP) into science curricula (Aikenhead, 2002; Banes & Dela Cruz, 2021; Cajete, 2000; McKinley, 1996; Michie, 2002). Other studies have explored the use of culturally relevant pedagogical practices in science teaching, such as the use of storytelling (Laughter & Adams, 2012) and community-based learning (Deyhle & Swisher, 1997; Moll, Amanti, Neff, & Gonzalez, 1992), culturally relevant virtual reality (Brown, 2021), and photo narratives (Goldston & Nichols, 2009). Zidny et al. (2020) suggested using *Didaktik* models and frameworks in designing science education that considers both the IKSP and Western science.

Potential and Possibilities of CRST

The potential and possibilities of CRST lie in its ability to transform science education into one that is more inclusive, culturally relevant, and empowering for learners from diverse backgrounds. CRST creates new pathways for understanding and appreciating the myriad ways that various cultures interact with and contribute to scientific knowledge by challenging the hegemony of Western science. As emphasized by Madkins and McKinney de Royston (2019), it "provides one promising pathway for addressing racial and economic inequalities in science education, including how students are perceived in relation to science disciplines and how they are positioned as capable learners and achievers" (p. 2).

Diverse cultural viewpoints and knowledge systems could be introduced into science education through CRST. Researchers documented IKSP and explained the science concepts embedded in those to be used in teaching or making instructional materials (Aikenhead, 2002; Banes & Dela Cruz, 2021; Baquete, Mutimucuio & Grayson, 2017; Handayani et al., 2019). The resulting strategy and instructional materials proved effective in teaching indigenous students. As Aikenhead (2002) highlighted, "culturally responsive teaching strategies and materials, integral to postcolonial school science, worked well for Aboriginal students in the pilot schools" (p. 299). Through integrating diverse cultural perspectives, CRST enhances the educational process and broadens the range of scientific understanding beyond the limitations of Western frameworks.

CRST empowers marginalized communities—like indigenous peoples—to acknowledge and value their distinct knowledge systems. In the 2007 consolidated report of the Episcopal Commission on Indigenous Peoples (ECIP) in the Philippines, indigenous groups pointed to mainstream education to be one of the reasons why there is deterioration of the IKSP and misuse and abuse of cultural practices. In addition, Cornelio and de Castro (2016) reported that out of 5.1 million IP youths, only 1.2 million were enrolled in elementary and secondary because they are being discriminated against for their "being backward, uncivilized or ignorant" (p. 162). CRST may empower marginalized communities by recognizing the value of indigenous science and traditional knowledge and by encouraging a sense of pride and significance in their scientific contributions.

Research on CRST has shown that this approach can lead to increased engagement and achievement and change in attitude among students from diverse cultural backgrounds. Mensah (2011) emphasized the need to foster collaboration in CRST, both in planning and implementation, for the students to engage in the lesson. Byrd (2016) showed that promoting cultural competence is associated with greater belongingness and achievement. Baquete, Mutimucuio, and Grayson (2017) revealed that contextualized instructional materials promote a positive attitude toward learning Physics.

CRST seeks to challenge Western science hegemony by centering diverse cultural perspectives and knowledge systems in science education. In traditional Western science, knowledge is often constructed and validated through objective observation, experimentation, and analysis (Mazzocchi, 2006). Doing this ignores the social and cultural contexts in which scientific knowledge is produced and can marginalize other forms of knowledge, such as those from indigenous, feminist, or postcolonial perspectives. In CRST, students are encouraged to critically examine the social and cultural factors that shape scientific inquiry and knowledge production as the "key distinction between scientific inquiry and culturally relevant science is the degree of emphasis on sociopolitical and critical analyses" (Boutte, Kelly-Jackson, & Johnson, 2010, p. 4). It expands the perspectives of what counts as scientific knowledge and inquiry and recognizes the contributions and validity of diverse ways of knowing and doing science.

With the use of CRST, teachers can help students from diverse backgrounds see themselves in science and view science as a tool for addressing issues relevant to their lives and communities (Laughter & Adams, 2012; Smith, 2022). As Boutte, Kelly-Jackson, and Johnson (2010) puts it "culturally relevant science teaching as a viable possibility for bridging the distances between school instruction and ways of knowing and realities within the homes and communities of culturally diverse students" (p. 2).

This approach can help to challenge the dominant narrative that Western science is the only legitimate way of understanding the world and can promote the recognition of other knowledge systems and ways of knowing (Laughter & Adams, 2012). Furthermore, culturally relevant science teaching can also help to promote social justice by addressing issues of equity and access in science education (Donato-Kinomis, 2016; Madkins & McKinney de Royston, 2019; Zidny et al., 2020). By recognizing the diversity of students' backgrounds and experiences and valuing and incorporating this diversity into science teaching, teachers can help ensure that all students have access to high-quality science education.

CRST is grounded on critical theory, which allows for examining power structures and forms of oppression. Critical theory, applied through CRST, challenges the hegemony of Western science and bridges different cultural and knowledge contexts (Strunk & Betties, 2019).

By embracing CRST, educators can help students from diverse cultural backgrounds see themselves as active participants in the scientific process and can help them develop a more nuanced and critical understanding of science as a social and cultural phenomenon. This approach can also help to create a more inclusive and equitable learning environment that recognizes the value and importance of diverse perspectives and experiences in scientific inquiry. Ultimately, CRST can help challenge the hegemony of Western science by broadening the definition of what constitutes scientific knowledge and promoting a more inclusive and socially responsible approach to science education.

Challenges in implementing CRST

Researchers critically evaluate the potential benefits of CRST as a transformative approach to science education. They emphasize that CRST promotes the preservation of culture, inclusion, and the incorporation of students' cultural backgrounds and knowledge systems into science instruction. They also delve into how CRST is implemented in the classroom, accentuating practices such as connecting science concepts to students' cultural contexts and integrating diverse examples and perspectives into lessons. A teacher who connects science concepts to students' cultural contexts is called culture broker. Aikenhead and Huntley (1999) described a culture broker science teacher as someone who "will help students move back and forth between their Indigenous culture and the culture of Western science and will help students deal with cultural conflicts that might arise" (p. 160).

However, they acknowledge the challenges teachers face in implementing CRST, including the need for teacher training and support, the availability of culturally relevant instructional resources, and the necessity to address deeply ingrained biases and beliefs within the education system. These articles contribute valuable insights into the potential benefits of CRST while shedding light on the practical challenges that need to be addressed for its effective implementation and impact on science education. Young (2010) revealed that challenges in the implementation of culturally relevant pedagogy were connected to the "deep structural issues related to teachers' cultural bias, the nature of racism in school settings, and the lack of support to adequately implement theories into practice" (p. 248).

In addition, Neri, Lozano, and Gomez (2019) emphasized that teacher's resistance to implementing a culturally relevant education (CRE) stems from their "(a) limited understanding, and belief in the efficacy, of CRE and (b) a lack of know-how needed to execute it (p. 202)". Among the components of culturally relevant pedagogy, teachers did not practice cultural competence and sociopolitical consciousness (Madkins & McKinney de Royston, 2019; Pejaner & Mistades, 2020). Some teachers were unprepared to address diversity and social and racial inequalities (Young, 2010). Integrating sociopolitical consciousness is affected by the teacher's dispositions and ideologies (Madkins & McKinney de Royston, 2019). Eventually, the teacher's dispositions and ideologies are acquired by the students. Their dispositions and doubts are the main reasons for their resistance to using CRST (Neri, Lozano, & Gomez, 2019). Aside from that, institutional norms and lack of inclusive tools also affect their implementation of culturally relevant pedagogies (Kolovou, 2022).

Science teachers do not see the importance of culture because of a lack of understanding and training in teaching students of different cultural backgrounds (Mensah, 2011; Neri, Lozano, & Gomez, 2019; Pejaner & Mistades, 2020; Young, 2010). Teachers must be trained during their pre-service years to assess their growth and development as culturally relevant teachers (Mensah, 2011). There are also limited references or resources, knowledge, skills, support, and appreciation of IKSP (Banes & Dela Cruz, 2021; Neri, Lozano, & Gomez, 2019). Furthermore, teachers think culture only applies to social sciences, not hard sciences (Boutte, Kelly-Jackson, & Johnson, 2010).

Banes and Dela Cruz (2021) point to globalization and modernization as threats to using culture in education. Globalization and modernization have changed the perspectives and landscape of education throughout the years. In this sense, culture is disappearing as new knowledge and practices are introduced. They also added that the "absence of explicit university policy/memorandum and monitoring scheme on the IKS integration in the curriculum, teaching methodologies, and pedagogies impede the sustainable integration of IKS (Indigenous Knowledge System) in the different subjects" (p. 19).

The standards and workload set by mainstream education also affect the use of CRST. Teachers are pressured to mold their students to attain grade-level standards (Madkins & McKinney de Royston, 2019) or pass standardized tests (Laughter & Adams, 2012), which are sometimes unrealistic for their situation. Standardized curricula and testing disregarded culture in education (Aronson & Laughter, 2016). Instead of making teaching and learning relevant to the students, they focus on attaining these standards.

On the other hand, some teachers think CRST demands a lot of time and effort (Mensah, 2011). With their workload, it is difficult for teachers to plan, research, discuss, teach, know their students, and immerse in the community simultaneously, especially if they do not share common cultural beliefs and practices. Knowing the students and immersing in the community are important to integrate sociopolitical consciousness.

Implications for the Future of Science Education

CRST has the potential to challenge and transform Western science hegemony in science education. Although Western science and traditional knowledge offer different paths of reasoning, they are from the same reality (Mazzocchi, 2006). Thus, the unique knowledge system of non-Western countries is also equivalent to Western science. There are no explicit policies on integrating cultural or indigenous knowledge systems and practices sustainably in these areas (Banes & Dela Cruz, 2021).

The supposed interface points between Indigenous Peoples Education (IPED) and the national education system are not observed even in IP schools (Pejaner & Mistades, 2020). To fully realize the potential of CRST, there needs to be more investment in instruction through teacher training, curriculum development, and assessment (Aikenhead & Huntley, 1999; Madkins & McKinney de Royston, 2019).

The literature shows a variety of reviews and perspectives on CRST. However, only a few empirical studies prove its effectiveness (Aronson & Laughter, 2016; Brown et al., 2019; Byrd, 2016). Theory-to-practice research shall help in exploring the empirical effects of CRST. Thus, future research on science education should focus on the effectiveness of CRST. The documentation of IKSP should be increased to help educators teach science (Handayani et al., 2019). When these IKSPs are explored, there will be a wide variety of teacher resources. This is necessary for teachers with different cultural backgrounds from their students.

CRST is seen to be vital in engaging students toward learning science and choosing science-related careers (Laughter & Adams, 2012). This approach will help students develop stronger identities and engage more in learning science. They could see how their realities require scientific understanding.

For CRST to be implemented successfully, diverse science teachers should be “deeply educated in science content in a culturally relevant way” (Laughter & Adams, 2012, p. 1129). A study showed that teachers might be aware of CRST. However, they do not know the pedagogical implications of it (Brown et al., 2019). With CRST, teachers should be able to address the achievement gap and make education ethical and imperative (Boutte, Kelly-Jackson, & Johnson, 2010).

Conclusion and Recommendations

The purpose of this work is to present a comprehensive examination of Culturally Relevant Science Teaching (CRST) and to explore its implications for practice, future research, and challenging hegemony in science education. Specifically, it aims to examine the historical context of Western science hegemony in mainstream science education and the exclusion of non-Western knowledge systems from mainstream science education; the context of CRST and how it challenges the hegemony of Western science in science education; and the potential benefits of CRST and how it is implemented in the classroom and the challenges it faces.

The historical context of Western science hegemony traces its roots to the Scientific Revolution, the intertwined relationship with feudalism, and the expansion of European colonialism. It highlights how non-Western knowledge systems have been marginalized in science education, leaving a legacy that still endures. It also exposes the shortcomings of Western science, especially when it comes to solving social injustices and environmental issues, as well as its propensity to ignore other cultural viewpoints. The results highlight the necessity of a paradigm change in the science education theory. A reassessment of science education is needed due to the dominance of Western science, which has its roots in historical elements like colonialism and feudalism. Decolonization and incorporating many knowledge systems into curricula are calls that are in line with a more culturally relevant methodology. Theoretical frameworks should challenge the traditional Eurocentric perspective by recognizing the interdependence of science, culture, and history. A re-evaluation of educational priorities is also prompted by the realization of the limitations of Western science, with an emphasis on the significance of context for scientific comprehension and the worth of varied modes of knowledge. This requires a more inclusive and culturally sensitive approach to STEM teacher preparation and challenges the conventional theory-to-practice split.

CRST is a pedagogical approach that aims to challenge the hegemony of Western Science by incorporating culturally relevant content, practices, and perspectives in science education. It was developed in response to minority struggles, prejudice, and Eurocentrism in science education. In particular, indigenous students faced many challenges. CRST integrates cultural referents into science teaching with the intention of empowering students. It is based on Culturally Relevant Pedagogy (CRP). Cultural competency, critical consciousness, and academic performance are the three main requirements for meaningful learning in CRST. The method dispels the idea that indigenous knowledge is inferior and acknowledges the close relationship between science and culture. It should be noted that CRST only aims to incorporate the indigenous knowledge systems and practices to make learning relevant. It does not justify dangerous practices nor claims to continue such practices. CRST is grounded in the principles of critical pedagogy, which emphasizes the importance of questioning and challenging dominant knowledge systems and power structures. The results demand a rethinking of teaching approaches and challenge the prevalent Eurocentric narratives in science education. The increasing importance of integrating indigenous knowledge systems and culturally appropriate pedagogies demonstrates the necessity for theoretical frameworks that bridge the gap between indigenous knowledge and Western science. The study offers Didaktik models and frameworks as possible instruments for creating science curricula that integrate Western science and indigenous knowledge systems, offering a theoretical basis for a more inclusive and culturally sensitive method of teaching science.

The potential and possibilities of CRST can revolutionize science education by fostering inclusive, culturally relevant, and empowered learning environments. By incorporating various cultural viewpoints and knowledge systems into the curriculum, CRST subverts the dominance of Western science. However, implementing CRST will present certain difficulties, including the requirement for teacher preparation, the lack of culturally appropriate materials, and the need to overcome ingrained prejudices in the educational system. This paper argues that making teaching and learning meaningful and relevant should be prioritized. Science teaching should focus on understanding how science is important in daily life. Students should see how science is done in their context and that it is not far different from Western science. The work advances critical theory by highlighting the use of CRST to analyze power dynamics and question the supremacy of Western science. CRST promotes a critical and nuanced view of science as a social and cultural phenomenon by providing a theoretical framework that spans many knowledge and cultural contexts. It affirms various approaches to understanding and performing science and questions the limited perspective of scientific knowledge building.

When educational institutions embrace the transformative potential of CRST, they can move beyond rhetoric and actively work toward challenging the Western science hegemony. To do this, CRST should be integrated and institutionalized in science education. This ensures a comprehensive and sustained implementation of CRST. CRST should be primarily integrated into the national science education curricula, ensuring cultural relevance is embedded in instructional materials, teaching methodologies, and learning objectives. This entails reviewing the current curriculum systematically and modifying it to meet CRST's objectives better. Extensive training and professional development programs should be provided for science educators to enhance their understanding of CRST principles and methodologies. Moreover, creating culturally appropriate teaching materials and offering science educators thorough training on CRST concepts are essential to a successful CRST implementation. This entails planning conferences, workshops, and resource development to enable educators to integrate CRST efficiently.

CRST should also involve community engagement and policy advocacy. Working with local communities is essential to guaranteeing that CRST practices are authentic. It is critical to advocate for policies that publicly acknowledge the value of CRST in science education to bring educational policies into compliance with cultural inclusion. Finally, it is critical to cultivate a culture of research, assessment, and international collaboration. Implementing evaluation mechanisms that align with CRST goals, ongoing research on the impact of CRST, and facilitation of international collaboration contribute to the global exchange of best practices in CRST and its continuous improvement.

Implementing these steps requires a task force comprising educators, researchers, community representatives, and policymakers. Furthermore, guidelines for CRST integration should be created, providing curriculum developers and teachers with a road map. Pilot programs can serve as learning laboratories in various contexts, offering insightful information and constructive criticism for ongoing improvement. Establishing partnerships with cultural organizations, non-governmental organizations, and local authorities is essential to guarantee ongoing community involvement. By adhering to these guidelines, educational institutions can actively challenge the hegemony of Western Science and promote a more diverse and culturally relevant science curriculum.

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