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EDITED BY
Ariel Mariah Lindorff,
University of Oxford, United Kingdom

REVIEWED BY
H. Prentice Baptiste,
New Mexico State University, United States
G. Nathan Carnes,
University of South Carolina, United States

*CORRESPONDENCE
Stacy Vasquez
✉ Svasquez@DallasCollege.edu

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Science for some: examining representations of relevancy and multiculturalism in Texas biology standards and textbooks

Stacy Vasquez[1]* and Erin D. Atwood[2]

[1]Department of Biology, Dallas College – Mountain View Campus, Dallas, TX, United States, [2]Fort Worth Independent School District, Fort Worth, TX, United States

Curriculum standards play an important role in the development of instructional materials considering they are used as a framework by publishing companies to outline textbooks. Therefore, it is imperative that standards and instructional materials integrate relevant interdisciplinary content that fosters the development of scientific literacy, health literacy, environmental literacy, and multicultural awareness. This qualitative research critically examines the Texas Essential Knowledge & Skills (TEKS) biology standards and three commonly adopted biology textbooks to determine the degree of relevancy and inclusion of multicultural content using James A. Banks' Levels of Integration of Multicultural Content. The researchers found that the inclusion of concepts of relevancy and multiculturalism are absent or minimal from the standards and textbooks and conclude that curricular transformation is needed to prioritize and support relevancy and multicultural teaching and learning in biology classrooms. Opportunities to enrich biology standards and textbooks that fall within the transformative approach and social action approach of Banks' Levels of Integration of Multicultural Content to promote relevancy and multiculturalism are presented.

KEYWORDS

multicultural science education, scientific literacy, health literacy, environmental literacy, relevancy, culturally responsive practice, critical discourse

Introduction

The problem and context of science standards

Understanding the basic foundations of biology can assist individuals from various social groups in making informed decisions that may improve their quality of life (Parker et al., 2003; United Nations Educational Scientific and Cultural Organization, 2010). A quality biology education has the potential to improve population health and promote a responsible, informed public (Kolstø, 2001). Every student in the United States is required to take a biology course with the intent of acquiring the knowledge necessary to navigate a scientifically advanced society (Teitelbaum, 2003; Plunk et al., 2014). National science standards provide guidelines for content in the curriculum to develop student's basic competencies in biology. Standards also play an important role in the development of curricular materials considering they are used as a framework by publishing companies to generate textbooks.

However, the development and revision of standards have been problematic for a few reasons: (1) Publishing companies have been known to adapt materials to meet state standards,

making way for the alteration of scientific knowledge and understanding by eliminating controversial content and promoting specific values and beliefs that may not be consistent with scientific thinking (Mead and Mates, 2009; Strunc, 2017). (2) Textbook content may be shaped by the values of the state and reduce the quality of content. For example, the Texas State Board of Education (SBOE) has approved biology standards that eliminate climate change, scientific consensus regarding evolutionary theory, and important topics related to sexual and physical health (Valentine et al., 2013; Hall et al., 2016; Watts et al., 2016; Foss and Ko, 2019; Hall et al., 2019). (3) While current national standards have undergone revisions with sections on diversity, equity, and inclusion, standards have failed to adequately address factors such as socioeconomic status, gender, and race (Rodriguez, 1997; Rodriguez, 2015). (4) Standards often lack relevance and exclude critical elements of multicultural science education which undermines efforts to promote diversity, equity, and inclusion (Stein et al., 2001; Finn et al., 2006; Wiley and Barr, 2007; Bhattacharjee, 2009a,b). (5) Traditional, discursive scientific practices continue to widen inequalities in student's learning outcomes (Brown, 2006). Therefore, it is imperative that state standards integrate relevant interdisciplinary statements that foster the development of scientific literacy, health literacy, environmental literacy, and multicultural science education awareness.

Relevance and literacy in the science curriculum

Research has shown that integrating contemporary socio-scientific issues into biology classrooms can improve overall attitude, motivation, and trust in science (Rannikmae et al., 2010; Lederman et al., 2014; Gutierez, 2015; Talens, 2016). Hulleman and Harackiewicz (2009) found that students displayed more positive attitudes when instructed using an interdisciplinary curriculum that allowed them to make connections between science, history, and economics. Culturally responsive teaching approaches integrated into science classrooms with students from traditionally underrepresented groups have also been shown to increase interest and motivation in science (Bang and Medin, 2010; Brown, 2017). However, biology classrooms continue to subject students to rote memorization of cycles, stages, and phases, ultimately inhibiting the development of an informed populace (Reiss et al., 1999; Osborne, 2010; Bazzul, 2014; Gardner, 2016).

To shift away from rote memorization and situate learning in meaningful contexts for students, it is important to promote relevancy and literacy in science education. The term, 'relevance,' has been used extensively in science education with no clear consensus regarding its meaning and application (Stuckey et al., 2013). The three dimensions of relevance as described in Stuckey et al.'s (2013) model aim to clarify the multi-faceted nature of the term, breaking it into the individual dimension, societal dimension, and vocational dimension. These overlapping dimensions define relevancy as fostering the development of skills necessary for people to responsibly operate as healthy, informed individuals in both personal and professional settings (Stuckey et al., 2013). The model ultimately underscores the importance of drawing connections between science and society rather than placing emphasis solely on content. Science educators and policy makers often cite the importance of relevance in curriculum reform efforts to promote scientific literacy, health literacy, and environmental literacy. The researchers recognize the collective importance of scientific literacy, health literacy, and environmental literacy to create a more equitable curriculum in multicultural science education (Figure 1). Similarly, 'literacy' has also taken on multiple meanings and plays a major role in science, health, and environmental education (Dillon, 2016). These literacies often draw connections between the individual, science, and society (Dillon, 2016; Finn and O'Fallon, 2017; Lindsey et al., 2021; Syahmani et al., 2021). The next three sections describe the impact of scientific literacy, healthy literacy, and environmental literacy on students from marginalized groups.

Scientific literacy

To be considered scientifically literate, individuals must possess a basic understanding of concepts related to science. This can be measured based on an individual's knowledge of science, their ability to reason using science, and their attitudes toward science. Bašnáková et al. (2021) found that anti-science attitudes are correlated with low-scientific reasoning and knowledge, which can have a negative impact on scientific literacy of the general population. A reason for this may result from low levels of reading comprehension. In Shaffer et al. (2019), SAT reading scores were a major predicter for success on the Test of Scientific Literacy Skills (TOSLS), highlighting the importance of reading comprehension in the development of scientific literacy. At present, reading comprehension in the United States is relatively low compared to countries such as Japan and Finland [U.S. Department of Education, National Center for Education Statistics (NCES), 2019]. Furthermore, students of color from communities of low-SES have the lowest levels of reading comprehension (Soliman, 2017). Collectively, students from such groups tend to have lower levels of achievement in science classes, often due to inequalities in education that predict the level of scientific literacy (You et al., 2021).

Instead of limiting scientific literacy to a set of rigorous and fixed outcomes, literacy should involve developing scientific competencies that relate to individual and societal needs (DeBoer, 2000). Scientific

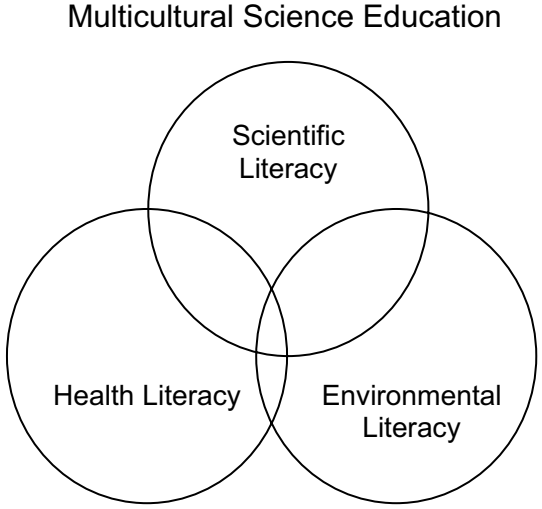

FIGURE 1
A Venn diagram illustrating the collective importance of scientific literacy, health literacy, and environmental literacy and their relationship to multicultural science education.

literacy can be promoted in the classroom in several ways: (1) focusing on personal and societal relevance, (2) strengthening general reading comprehension by encouraging students to interact with science-based media reports, magazines, and works of fiction, (3) demonstrating how to objectively analyze scientific claims to differentiate between reliable information and misinformation, (4) highlighting the historical aspects of the scientific enterprise by discussing contributions made by a variety of cultures, and (5) encouraging students from traditionally marginalized groups to participate in the present day scientific enterprise (Zucker, 2021). Educators can also encourage students to use socio-scientific modeling to incorporate social factors and make information more relevant to their lived experiences (Ke et al., 2021). The socio-scientific model is a multidisciplinary method of instruction, linking scientific concepts to history, economics, and culture. This model also affords an opportunity for students to examine socio-scientific issues not just from the perspective of the individual, but at the population level as well. Research has demonstrated that teaching science through a socio-scientific lens can help motivate students to participate in science, increase their interest in science, and help to develop their scientific literacy skills (Lederman et al., 2014; Gutierez, 2015; Talens, 2016).

Health literacy

Health literacy has been broadly defined as possessing the knowledge necessary to communicate, interpret, and disseminate health-related information at the individual and population level (Leger, 2001; Parker et al., 2003; Peerson and Saunders, 2009). This can involve an informed discussion between doctors and their patients, the ability to read and follow prescription label instructions, avoiding risk exposures that threaten the population, and interpreting nutrition labels. Health literacy is comprised of two parts: (1) Personal health literacy: Individuals who can locate, understand, and use health related information and services to make informed decisions regarding their health, their family's health, and their community's health possess a high degree of personal health literacy. (2) Organizational health literacy: Organizations that provide equitable access to their services, enabling individuals to locate, understand, and use health related information to make informed decisions regarding their health possess a high degree of organizational health literacy (Pitts and Freeman, 2021). However, individuals from traditionally marginalized and underserved populations often possess a low degree of health literacy, manifesting in the form of chronic illnesses such as obesity, type II diabetes, hypertension, and cardiovascular disease (Becerra et al., 2017; Jacobs et al., 2017; Verney et al., 2019; Feinberg, 2021; Yiğitalp et al., 2021).

Such disparities can be addressed by creating culturally competent materials that eliminate cultural and language barriers. These materials may build trust in the public health infrastructure, thereby increasing organizational and personal health literacies (Spinner et al., 2021). Some educational institutions have created culturally competent curricula aimed at educating students on health disparities that impact underserved populations. For example, prior research has described how programs (e.g., pharmacy and medical schools) implemented cultural competence in their curriculum to improve student knowledge, skills, and attitudes (Jernigan et al., 2016; Lindsey et al., 2021). Implementation of culturally competent content in existing curricula may adequately prepare medical professionals in reducing health disparities. Additionally, inclusion of culturally competent content in standard health and biology education may help to improve knowledge, attitudes, and skills related to personal health literacy in students from underserved communities heavily impacted by health disparities.

Environmental literacy

The North American Association for Environmental Education defined environmental literacy as, "an awareness of and concern about the environment and its associated problems, as well as the knowledge, skills, and motivations to work toward solutions of current problems and the prevention of new ones (McBride et al., 2013, p. 3)." Given the nature of our complex interactions with the surrounding environment and the influence it has on population health, policy makers have integrated environmental literacy into curriculum reform efforts. National standards include the impact of anthropogenic changes on the environment, thus encouraging teacher professional development programs geared toward environmental education (NGSS, 2013; Hufnagel et al., 2018). Environmental programs may situate learning in local contexts with field-based activities to foster student interest, knowledge, and sensitivity toward environmental issues, and the development of responsible behaviors and healthy lifestyles (Carter and Simmons, 2010; Pateman et al., 2021).

Some early childhood educators have applied environmental education models focusing on water quality, waste management, energy management, and sustainable agriculture to increase their students' conceptual knowledge on the interdependence between nutrition, the environment, and health (Erdogan, 2015; Shafer, 2017; Bayer et al., 2020). While these environmental education programs aim to promote environmental literacy, there are barriers such as costs and potential liabilities when participating in field-based activities (Kinslow et al., 2019). Schools that participate in these programs tend to have more financial resources and administrative support, whereas underserved communities may not have equitable access to facilitating environmental education (Tannock, 2020).

Environmental literacy is particularly important for marginalized communities that experience negative environmental outcomes. Some of these issues include exposure to air pollution, living in poor quality housing, and consumption of contaminated drinking water, all of which may contribute to the development of certain cancers, cardiovascular illness, and lower life expectancy (Chi et al., 2016; Hughes et al., 2017; Switzer and Teodoro, 2018; Hill et al., 2019; Boch et al., 2020; Terrell and St Julien, 2022). Promoting environmental literacy may help empower them to address environmental issues negatively impacting their lives. Content related to environmental health literacy and environmental justice have been implemented into traditional science courses for the purposes of creating relevance for students from underrepresented groups. For example, Lasker et al. (2017) discussed a green chemistry curriculum that integrated relevant course content surrounding issues of social justice, health, and the environment. The authors underscored the importance of empowering future chemists, particularly those coming from underrepresented groups, to view themselves as change agents capable of preventing and solving environmental justice issues.

Adkins-Jablonsky et al. (2020) investigated the impacts of a course-based undergraduate research experience in microbial ecology focused on examining contaminated soil samples collected from a predominantly African American community. They found the community-based experience increased students' level of science identity, efficacy, and engagement with the course content.

Social, cultural, and political factors as elements of science education

Science is often viewed as an apolitical discipline free from bias, adhering to a set of principles that guide inquiry into the natural world. However, science is value-laden with deeply embedded inequities and injustices that are maintained through various social, cultural, and political factors (Wingfield, 2020). Science education continues to lack relevance for many diverse learners from traditionally marginalized groups. These groups include people of color, women, members of the LGBTQIA+ community, and those living in areas of low-socioeconomic status (SES), often with intersections existing between them. The lack of relevance fails to adequately prepare students to successfully navigate life as it relates to science and to pursue STEM based careers. This can be seen when analyzing population statistics regarding chronic illness, the low number of people from traditionally marginalized groups working in STEM, and the low degree of the previously discussed literacies (Rannikmae et al., 2010; Onwu and William, 2011). In addition to content that is irrelevant to student's lived experiences, students also face difficulties with adjusting to traditional, discursive practices presented from a Westernized perspective (Brown, 2006; Dillon, 2016). Archer et al. (2015) conducted longitudinal interviews among a group of African American students and found they view careers in science as less achievable due to social inequities and stereotypes that exist in the home and school environment. Researchers from the LGBTQIA+ community have also reported feeling a lack of acceptance in the STEM community in the form of career limitations, discrimination, and harassment, often leading to heightened intentions to leave the field entirely (Freeman, 2020; Cech and Waidzunas, 2021).

Cultural diversity is often excluded from standards and curricular materials in science (Atwater, 2010). Several articles have been published that aim to uncover cultural misrepresentations and the absence of outside cultural narratives in the social sciences, yet this phenomenon is seldom explored in the natural sciences (Olivo, 2012; Vasquez Heilig et al., 2012). Science texts often ignore or minimize the contributions of Middle Eastern and African science and are dismissive of indigenous scientific knowledge (Snively and Corsiglia, 1998; Iaccarino, 2003; Drenth, 2011). For example, Ibn Al-Haytham developed the scientific method long before Western scientists, yet the process is often described by textbooks as a set of steps with no associated originator (Añel, 2019). Considering science has been practiced by a variety of cultures across time, it is important for science standards to encourage the production of curricular materials that promote awareness and inclusivity beyond western science (Leite, 2002; Alexakos and Antoine, 2005).

Promoting multicultural awareness in science can inform students about historical and contemporary science issues that continue to affect marginalized groups (Leite, 2002). This form of culturally responsive teaching can help students feel more included, transition into a new learning environment, think critically about social justice issues surrounding science, and develop a stronger commitment to their community and culture (Aikenhead, 2001; Atwater, 2010; Morales-Doyle, 2017). While attempts have been made to include traditionally underrepresented groups in curricular materials, important figures of backgrounds continue to be excluded (Blickenstaff, 2005; Olivo, 2012). For example, Dr. Lydia Villa-Komaroff, one of the first Mexican Americans to obtain a PhD in the natural sciences and lead scientist in a team of researchers that discovered the potential for human insulin synthesis in *E. coli* (Villa-Komaroff et al., 1978) is seldom mentioned in traditional biology textbooks. Within male dominated STEM fields, women continue to occupy careers in lower numbers, attend fewer academic conferences, and serve less on editorial boards (Sheltzer and Smith, 2014; Lerback and Hanson, 2017). Light et al. (2022) reported changes in perception of STEM based careers depending on the level of participation by women; STEM fields that garner more participation of women are more likely to be considered "soft" science while more male dominated STEM based careers are seen as "hard" sciences. This change in perception can cause certain STEM fields to be considered less rigorous, less worthy of funding, and having less value.

Poor learning outcomes are perpetuated by economic inequities and discursive scientific practices that fail to engage students in meaningful, culturally relevant contexts [Bacharach et al., 2003; Cohen et al., 2009; National Center for Education Statistics (NCES), 2012; Strachan, 2017]. Eurocentric knowledge and hegemonic practices in education deter teachers from addressing oppressive practices that are harmful to students from marginalized groups (Boutte et al., 2010). Therefore, it is vital to create curricular materials that will better engage students from traditionally marginalized groups. In addition, professional development programs may educate teachers on the value of relevancy and multiculturalism in the science curriculum.

Standards and textbooks as official (hidden) science curriculum

Curriculum involves a combination of formally approved learning objectives, lesson plans, and activities used by educators to guide students during their course of study. However, the unseen, unspoken, unwritten, yet highly influential features of the curriculum exist as a part of the hidden curriculum and can have significant negative impacts on learning outcomes for students from marginalized groups (Small, 2020). For instance, Donovan (2014) identified a section within a genetics textbook that inadvertently reinforced racial biases among the eighth-grade students participating in the lesson plan. Chuang et al. (2010) examined the hidden curriculum present within medical school education and found that it can negatively distort students' perception of the doctor-patient relationship, suggesting the potential development of an amoral approach to medical practice post-graduation. It is the ways in which the curriculum is structured, through a set of recognized standards, cultural norms, and power dynamics that ultimately shapes teaching and learning.

Standards as they exist today continue to promote the development of value-neutral curricular materials grounded in content-driven classrooms where students participate in activities that leave them uninformed and uninspired (Reiss et al., 1999). Standards guiding curriculum and instruction are a collection of

statements formulated by varying levels of government entities that determine what knowledge and skills are necessary for student success. Common Core standards were developed by multiple states in the United States, the Council of Chief State School Officers (CCSSO), and the National Governors Association Center for Best Practices (NGA Center), in attempts to create consistency in what content should be taught in mathematics and English language arts classrooms across the country (Porter et al., 2011). In response to the absence of common core standards for science, the Next Generation Science Standards (NGSS) were created through a collaborative effort involving multiple states, the National Research Council (NRC), National Science Teachers Association (NSTA), and the American Association for the Advancement of Science (AAAS), thus providing a set of newly revised science standards to guide meaningful classroom instruction (Reiser, 2013).

Nevertheless, states are not required to adopt national standards, giving each state the option of creating its own standards. Independent standards are more often created in states, such as Texas, where certain ideas and understandings within the standards are misaligned with attitudes, values, and beliefs prevalent in the state (Valentine et al., 2013). Texas has not adopted Common Core, and instead follows the Texas Essential Knowledge & Skills (TEKS) as its curricular standards for all grade levels and subject areas. These standards are created through a process with the Texas Education Agency (TEA) and are approved by the State Board of Education. Ultimately, these standards determine what information is present within curricular materials. Texas now has over 5.4 million students [Texas Education Agency (TEA), 2023], which majorly influences textbook production and content. Texas is a major market for textbook publishers, and these companies will align the content with the state standards to increase their chances of being selected by schools throughout the state (Bhattacharjee, 2009a,b). This process not only impacts Texas curriculum, but also influences the content of textbooks produced for other states and materials that are distributed far beyond Texas classrooms (Stein et al., 2001).

Unlike the TEKS biology standards, NGSS includes a section describing human influence on climate change and the importance of sociocultural factors influencing ecosystems (National Research Council, 2013). Common Core, NGSS, and TEKS all include guidelines to improve acquisition of language and content knowledge in science for English Language Learners (ELL) (Lee et al., 2013). While Common Core, NGSS, and TEKS contain certain positive elements within their frameworks, they in many ways remain mechanistic, lack relevancy, and are minimally inclusive of statements surrounding multicultural science education content (Atwater, 2010; Rodriguez, 2015). Many state standards remain sub-par in their mention of topics surrounding climate, evolution, sex education, and race, being deemed too controversial for the classroom (Wiley and Barr, 2007; Watts et al., 2016).

The purpose of this research is to examine the TEKS biology standards and commonly used textbooks to determine the degree of relevancy and inclusion of multicultural science education content. Specifically, the researchers focused on issues of relevance that pertain to scientific literacy, health literacy, and environmental literacy. The analysis of multiculturalism will be limited to representations of race, gender, sexual orientation, and socioeconomic status. The specific questions are:

1. To what degree are elements of relevancy and multicultural science education present within the TEKS Biology Standards?
2. To what degree are elements of relevancy and multicultural science education present within commonly adopted Texas biology textbooks?

Theoretical framework

Critical discourse analysis

To determine the degree of relevancy of multicultural science education in the standards and textbooks, the researchers chose Critical discourse analysis (CDA) as a framework considering it has been used to examine how the structure and content of language function to influence society with the intent of speaking to or intervening in socio-political issues, problems, and controversies (Gee, 2004). CDA can be used to reveal the complex interplay between language and society in educational contexts. Using CDA, the TEKS biology standards and three commonly adopted biology textbooks were examined to determine if the standards and textbook content were relevant to the needs of the population and inclusive of multicultural science education content. A similar study utilized a Foucauldian discourse analysis to critically examine secondary biology textbooks for subjectivities that may be constituted through discourses surrounding ethics, sex/gender & sexuality, neocolonialisms, and neoliberalisms (Bazzul, 2014). According to the author, applying CDA to examination of secondary biology texts is necessary to challenge structures complicit in colonialisms, oppressions, and maintenance of exploitative economic regimes. By doing so, science educators can uncover subjectivities produced by curricular materials that maintain gender, race, and socioeconomic inequities, moving us further toward a critical, anti-oppressive science curriculum (Bazzul, 2014). The traditional curricular structure of science education shaped by the language found within standards and textbooks often utilize a fact-based approach, which places the teacher in the position of acting as the knowledgeable other responsible for conveying information to the student. This approach is inhibitory to discourse and has been reported as having negative effects on student performance (Osborne, 2010).

Levels of integration of multicultural content

This study differs in that the researchers are critically examining how language within state standards shape the official science curriculum by determining the level of representation of relevancy and multiculturalism in textbooks using James A. Banks's Multicultural Education framework. Banks defines five dimensions of multicultural education: content integration, the knowledge construction process, prejudice reduction, an equity pedagogy, and an empowering school culture and social structure (Banks and Banks, 2004). While all five dimensions are interrelated and essential for multicultural education, our work for this piece is most focused on the area of content integration. Banks details what he terms "The Levels of Integration of Multicultural Content." There are four levels:

TABLE 1 Adapted levels of integration of multicultural science education content.

0 – Partial/Absent	Lack of topics related to relevancy and Multiculturalism
1 – Additive Approach	Content related to relevancy and multiculturalism is added in a superficial manner without changing the structure of the standards and curriculum. Does not prompt students to think critically on socio-scientific issues related to relevance and multiculturalism.
2 – Transformative Approach	Standards and curriculum have been transformed to include topics related to relevancy and multiculturalism, though students are not prompted to engage with the content socially and politically.
3 – Social Action Approach	The standards and curriculum are designed to enable students to participate in discussion regarding contemporary biology issues as it relates to relevancy and multiculturalism, encouraging them to engage socially and politically.

contributions, additive, transformation, and social justice approaches. The rationale for using Banks's work is that his framework is grounded in critical theory and explores the power relationships that aim to suppress knowledge, particularly as it relates to understandings of history. Therefore, the researchers chose Banks's framework to examine multiculturalism in biology standards and textbooks.

For the purposes of this study, the researchers modified Banks's Levels of Integration of Multicultural Content (Banks, 1993). While Bank's framework highlights multicultural significance and the need to advocate for inclusion in the social sciences, the researchers' version was modified to include science education content. Rather than utilizing the original four levels (1–4) within the original framework, the researchers added in a level zero and combined the first and second levels, resulting in the following framework: Absence (0), Additive Approach (1), Transformative Approach (2), & Social Action Approach (3), as described in Table 1.

Materials and methods

Data sources

Standards from Chapter 112 of the Texas Essential Knowledge & Skills (TEKS) for Science, Subchapter C. High School, section §112.34. for Biology were obtained from the Texas Education Agency website.[1] To determine which textbooks to review, the researchers identified 25 school districts with the largest student enrollments in the state, representing around 40% of the total student population in Texas. They then identified which textbooks these districts adopted for high school biology. One of the three textbooks reviewed were adopted by all but one the 25 districts identified. As a result, the following textbooks were reviewed: Houghton Mifflin Harcourt Texas Biology (Teacher's Ed.), Pearson Texas Biology (Teacher's Ed.), and McGraw Hill Glencoe Biology (Teacher's Ed.).

Coding and consensus

The TEKS biology standards were critically examined for the presence of concepts related to definitions of relevance and multiculturalism as described in the literature review. The researchers discussed what details constituted relevance and multicultural science education prior to coding. Each researcher coded the standards independently and later evaluated each other's conclusions to reach a consensus. The team examined a current copy of the TEKS biology standards taken from the Texas State Board of Education website, applying colored highlights to sections related to relevancy and multiculturism. Once a consensus was reached, the researchers proceeded to compare the identified standards to three commonly adopted textbooks.

For examination of the biology textbooks the researchers applied a similar coding mechanism used for the standards to identify the page numbers of interest, marking them with colored tabs. Adhesive notes containing a detailed description regarding the coders' interpretation of the content added to each page. Teacher editions were chosen for analysis considering they contained the TEKS biology standards with page numbers linked to supporting content. In addition, they have sidebar content that contains teaching suggestions that are not present in student editions. Various elements of each page number were analyzed including text from body paragraphs, sidebars, figures/graphs, and visuals (e.g., illustrative representations, portraits). While CDA often seeks to understand the function of language in a written and spoken context, it has been applied in multimodal contexts placing emphasis on visual literacies (Han, 2015). The importance of visuals in developing literacies have been reported in both health care and educational settings (Tillmann, 2012; Arlt and Geraldi, 2015). Therefore, the researchers considered the size, position, and context of the images during analysis.

The researchers formed a consensus, noting similar interpretations of the content. In a few cases, they identified content that was not recognized by the other. To address this, interpretations were discussed and a consensus was formed to either keep or omit the code. In each case, interpretations formed by the other were reconciled to develop the final codes.

Results

Positionality statement

The standards and textbooks were examined using critical discourse analysis (CDA). Therefore, the researchers describe, interpret, and explain the findings, often interjecting their own values, to convey the ways in which social inequalities are maintained through the examined materials.

TEKS biology standards

After examining the TEKS Biology Standards, it was found that they provided little focus on relevancy and multicultural education.

1 https://tea.texas.gov/sites/default/files/ch112c.pdf

The following section will provide specific examples of the researchers interpretations of the standards with regard to relevancy and multiculturalism.

Scientific literacy

The introduction section of the TEKS Biology Standards, (b)(1), states that students will have opportunities to "make informed decisions using critical thinking and scientific problem solving." It does not mention what types of decisions will be made, nor does it relate to aspects of identify such as race, gender, sexuality, and SES. Section (b)(4) states that, "students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information)." It does not mention the fact that there is a relationship between scientific decision making and ethical/social decisions involving science (application of scientific information). Section (c)(3), Scientific processes, "The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom." This section does not specify the types of informed decisions that must be made inside and outside of the classroom, particularly as it relates to issues impacting students based on aspects of relevancy and multiculturalism. The section further described that students should be able to, "communicate and apply scientific information extracted from various sources such as current events, published journal articles, and marketing materials; draw inferences based on data related to promotional materials for products and services; and evaluate the impact of scientific research on society and the environment." It does not state that students should be able to differentiate between reliable information and misinformation.

Health literacy

The introduction section (b)(1) stated that students will explore "structures and functions of cells and viruses; growth and development of organisms; cells, tissues, and organs and genetics; biological evolution; taxonomy; metabolism and energy transfers in living organisms; living systems; homeostasis." It does not mention the importance of understanding the development of chronic disease that impacts marginalized communities and how environmental placement can impact can have a strong influence. Section (5)(C), Science concepts, "recognize that disruptions of the cell cycle lead to diseases such as cancer." This section fails mention the fact that there are specific environmental factors that contribute to the development of cancers, particularly among people from traditionally marginalized groups. Section (9)(A) states, "compare the functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids." It does not mention biomolecules are related to everyday life, such interpreting a nutrition label. It also does not require students to explore how chronic illnesses impact marginalized communities. Section (10)(A) states that students should be able to, "describe the interactions that occur among systems that perform the functions of regulation, nutrient absorption, reproduction, and defense from injury or illness in animals." It does not require students to think of body systems in terms of relevancy or multiculturalism. Section (11)(A) states that students should be able to, "summarize the role of microorganisms in both maintaining and disrupting the health of both organisms and ecosystems." This standard does not emphasize the impact on marginalized communities.

Environmental literacy

The introduction section of the TEKS Biology Standards states that students will learn about "ecosystems and the environment." Section (c)(1)(B), Knowledge and Skills, Scientific processes, states that student will, "demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials." It does not describe how students should know how pollution impacts marginalized communities. Section (3)(D), scientific processes, states that students will, "evaluate the impact of scientific research on society and the environment." The standard does not discuss human influence and the impact it has on people from marginalized communities. Section (5)(B) stated, "describe the roles of DNA, ribonucleic acid (RNA), and environmental factors in cell differentiation." This standard does not mention how environmental factors can lead to the development of certain conditions such as cancer. Section (11)(A)(B) states that students will be able to, "summarize the role of microorganisms in both maintaining and disrupting the health of both organisms and ecosystems and describe how events and processes that occur during ecological succession can change populations and species diversity." Section (12)(D)(E) states, "describe the flow of matter through the carbon and nitrogen cycles and explain the consequences of disrupting these cycles; and describe how environmental change can impact ecosystem stability." These standards do not require students to describe the impact that industries that pollute have on the disruption of ecosystems.

Multiculturalism

In the Biology TEKS, section (c)(4)(B) contains a standard that vaguely relates to multicultural science education. It states that students should be able to, "relate the impact of past and current research on scientific though and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content (Texas Education Agency (TEA), 2023)." The standard did not include explicit statements related to multicultural education, outside the inclusion of the word "diverse."

Biology textbooks

All three textbooks were grounded in rote memorization of discrete facts presented in isolation and made little effort to draw connections between concepts or to the lived experiences of students. The following section will provide examples describing the aspects of relevancy (e.g., scientific literacy, health literacy, & environmental literacy) and multiculturalism (race, gender, sexuality, and SES) that were present (or absent) in each textbook.

Houghton Mifflin Harcourt biology textbook

Scientific literacy

This book did not include a specific statement of scientific literacy. It did include sections on scientific thinking, accessing reliable primary/secondary sources, and the importance of evaluating scientific information, all of which are components of scientific literacy. There were "real-world connections" present throughout the text, though these connections were not very relevant to the lived

experience of students. For example, a "connect to your world" heading contained a paragraph regarding the sounds made by the human heart, something students can recognize as a part of their lived experience. Many of the "connect to your world" sections were presented in the same manner, lacking deeper connections.

Health literacy

This textbook did include content related to sex education, describing sexually transmitted diseases such as syphilis, gonorrhea, and chlamydia. It included the following statement regarding the avoidance of contracting STDs, "the surest ways are to abstain from sexual contact before marriage and for partners who do not have STDs to remain faithful in a committed relationship (Nowicki, 2015, p. 984)." The text further stated, "using a condom is the next saftest choice; however, a condom can break or tear." There were no statements regarding STD testing or how to access such resources, nor was there a section on preventative measures. The textbook did not discuss sexual education in the context of disease transmission as it relates to the disproportionate impact on marginalized communities.

A section discussed Type II diabetes a chronic illness that impacts adults and children and can arise from unhealthy dietary practices and sedentary lifestyle (Nowicki, 2015, pp. 828–829). It does not mention how communities of color in areas of low-SES are disproportionally impacted by Type II diabetes due to consumption of carbohydrate rich food sources, environments that are not conducive to exercise, and the likelihood of developing other chronic illnesses.

There was a section on nutrition presented in a superficial manner (Nowicki, 2015, p. 985). A link description directs students to a website that mainly focuses on how a healthy diet during pregnancy leads to a healthy baby but does not help students understand how poor dietary practices can lead to the development of chronic illness.

A section in the human systems chapter discusses lifestyle choices in the role of circulatory diseases resulting from a poor diet, smoking, increased stress, and lack of exercise. Students are asked to answer the question, "How can lifestyle choices affect the function of the arteries?" A figure is present on the following page displaying an image of an African American couple walking and states, "Exercise is an important factor in preventing heart disease (Nowicki, 2015, p. 885)." However, it does not explicitly state that communities of color are disproportionally impacted by the development of cardiovascular disease.

Environmental literacy

There is a statement that asks students, "How might biology help you to better understand environmental issues (Nowicki, 2015, p. 29)?" The same section asks students to question if chemical pollution "can pose a risk to people living in the area (Nowicki, 2015, p. 29)?," without mentioning how communities of color from low-SES are disproportionally impacted by pollution.

There was an air quality section stating that fossil fuels can accumulate in the air and was explicit in mentioning the role of the gas and oil industry. There were associated images showing factories with gasses moving into the environment. A section on renewable energy discussed the importance of developing renewable sources of energy (Nowicki, 2015, p. 473). Although it states, "How many people could earth support without electricity or gas, or if all construction had to be done by hand. Technological advances have allowed for continued human population growth (Nowicki, 2015, p. 473)," without prompting students to think of destruction of ecosystems and health problems that can arise from pollution. The statement, "the United States uses more resources and produces more waste than any other country on earth (Nowicki, 2015, p. 473)," encouraged students to think of their ecological footprints by, "[describing] how a population can use resources in a sustainable way." There is a section on drinking water and how it can become contaminated, but it does not expand on the fact that water contamination impacts communities of color in areas of low-SES, as in the case of Flint, Michigan. There is an activity where students can test water samples from their local area (Nowicki, 2015, p. 481). This could be a relevant activity that will provide students with an opportunity to examine water quality from a local context, but it does not mention that water quality varies based on SES. One section on climate change does provide a definition and shows students how to use data to substantiate claims regarding human influence. In addition, it states, "what information from the primary source could be taken out of context and use to support an alternate viewpoint (Nowicki, 2015, p. 500)?" The statement itself could be taken out of context and used to support the idea that there is not a major consensus regarding the effects of climate change. There was no section contained in this text regarding use of Genetically Modified Organisms (GMOs) in agriculture.

Multiculturalism

Regarding race, this textbook avoided explicit discussions surrounding race. Diagrams and figures of humans were largely white male and female representations or only had an outline of the human body with no indicator of race. There was a figure of an Asian man in a diagram highlighting the pancreas and discussing type I diabetes. In addition, there was a diagram featuring an African American male, highlighting the skeletal, muscular, and digestive systems. The integumentary system discussing the skin does not discuss the fact that there is no scientific basis for race and that it is a social construct with serious influence when navigating society. There is no mention of non-western scientists. The textbook contains diverse scientists scattered throughout the text in a "Career Highlights" section but none of the profiles explicitly state anything regarding their identity (e.g., gender & race).

Regarding gender, there were career highlights present on pages that included women, intersecting with race. From a historical viewpoint, there was the inclusion of Rosalind Franklin, the scientist who contributed to the discovery of the structure of DNA (Nowicki, 2015, pp. 221–223) The textbook does include a very small photo of Rosalind Franklin. In reference to her famous Photo 51, the textbook states, "Her coworker, Maurice Wilkins, showed the data without Franklin's consent to Watson and Crick, which helped them discover DNA's structure (Nowicki, 2015, p. 221)." It further states that she was not acknowledged at the time and was posthumously awarded the Nobel Prize following her death. There was no mention of the sexism or misogyny she endured. The textbook did include a section on Henrietta Lacks. It mentions that HeLa cells are commonly used in cancer research and, "…were originally obtained in 1951 from a cervical tumor removed from a woman named Henrietta Lacks (Nowicki, 2015, p. 143)." It does not discuss the fact that Henrietta Lacks was African American, nor did it mention unethical nature of obtaining the cells without her consent and how industry has profited off her cells. No image of her is present in the textbook.

Regarding SES, the textbook does not mention class differences that lead to varying experiences within the population that can have a substantial impact on education and health. Regarding sexuality, the

textbook does not mention any terms associated with the LGBTQIA+ community and presents issues disproportionally impacting the LGBTQIA+ community in a heteronormative way.

The textbook does include a "Differentiated Instruction" section presented throughout the text intended to help English Language Learners and students who are "below level." Further there is an "inclusion section" that helps the teacher present the information to students who are visually impaired. There are pictures of students of color performing activities, but this would be considered an additive approach, as it does not explicitly state why it is necessary to include such representations.

Pearson textbook

Scientific literacy

This textbook provided a definition of scientific literacy. At the end of the text there is a science skills handbook with a section titled "How is scientific literacy important when evaluating promotional materials (Miller and Levine, 2015, p. 914)," using the same language presented in the TEKS Biology Standards. While the textbook provides an accurate definition of scientific literacy, it does not require students to evaluate meaningful promotional materials. For example, students were to evaluate an advertisement on a website claiming to have a paid program that could increase test scores, prompting students to identify the small sample size and uncontrolled variables. This was a missed opportunity to have students examine pseudoscientific promotional materials that can be harmful to human health, or to examine a vaccine misinformation website.

The textbook does have "connect to…" sections on side bars related to the real world, chemistry, and the language arts to promote science as an interdisciplinary enterprise. Although the connections are not very relevant to the lived experiences of students. For example, a "Connect to the Real-World" section prompts students to talk about the importance of our vision and has them complete an activity where they are to wear goggles while throwing a cotton ball at each other (Miller and Levine, 2015, p. 841). This is to demonstrate the importance of the reflex process that protects us from the external environment and how vision allows us to find food, shelter, and mates. A "Connect to Language Arts" contains a quote from literature "using visual imagery to describe the earth (Miller and Levine, 2015, p. 67)" but it does not discuss the importance of having good reading comprehension to better understand science and to build scientific literacy. A "Connect to Chemistry" section is found throughout the text but focuses on objective facts associated with stages, phases, and cycles. For example, the chapter covering plants had a section on a connection between the chemical formula summarizing the process of photosynthesis and to have students write out the formula (Miller and Levine, 2015, p. 70).

There are sections throughout the textbook that prompt the instructor to "address misconceptions." One example intersects with health literacy as it aims to have students understand misconceptions associated with vaccines (Miller and Levine, 2015, p. 589). This example will be further described in the health literacy section of this textbook. An additional side-bar prompt aims to help students "Build Reading Skills." For example, the section on air pollution requires students to create an outline on the air pollution subsection presented in the chapter (Miller and Levine, 2015, p. 163).

Health literacy

There are "Connect to Health" sections throughout the book. However, these were weakly drawn connections lacking relevancy. For example, there is a section on understanding vaccines (Miller and Levine, 2015, p. 589) that does not prompt students to understand how vaccines work and to discusses anti-vaccination movements. There is a "addressing misconceptions" section presented in this text. In discussing the misconception that, "vaccines have serious, harmful side effects including illness and death (Miller and Levine, 2015, p. 589)," it states that "severe side effects are exceedingly rare" only to contradict this statement later by stating, "however, every vaccination carries with it the risk that the child being vaccinated will experience adverse reactions (Miller and Levine, 2015, p. 593)." The text also mentions that there should never be forced vaccine mandates. In a section related to emerging diseases, it discusses transmission of pathogens across the globe without cautioning the rise of xenophobia out of fear of becoming sick. Like the Harcourt textbook, the section describing HIV/AIDS was presented in a heteronormative manner, failing to discuss the historical crisis and disproportionate impact on certain groups such as people of color, low-SES, and members of the LGBTQIA+ community.

This text did not have a nutrition section. The only thing related to nutrition was an activity at the end of the textbook that requires the students to interpret a nutritional label and asks, "would you infer this is a good source of fiber (Miller and Levine, 2015, p. 915)?" It in no way addresses interpretation of a food label for sodium content, saturated fat content, and carbohydrate content, all of which can contribute to the development of chronic illness if consumed in high amounts. These foods are highly accessible to people of color in communities of low-SES. There was no mention of type II diabetes in this text. It only mentioned type I diabetes in a section describing autoimmune diseases (Miller and Levine, 2015, p. 889). This is a missed opportunity to connect diet with the development of type II diabetes and how certain communities are disproportionately impacted. There was a "quick facts" section in the cardiovascular system that discussed high blood pressure impacting African Americans due to genetic predisposition, and the value of knowing this information can help "encourage a person to take preventive measure, such as adopting a healthier lifestyle (Miller and Levine, 2015, p. 873)." It failed to discuss sodium consumption, carbohydrate consumption, and saturated fat consumption that can contribute to the development of hypertension and other associated chronic illnesses. It did not discuss the fact that such foods are highly accessible in communities of low-SES. There was a section discussing heart disease and the use of foxglove (Miller and Levine, 2015, p. 167) and the compound digitalis that could treat heart disease, but it fails to discuss communities in need of such treatments, or that communities of color often do not have health insurance and financial resources to treat heart disease. A section discussing the controversy surrounding stem cell research and how it can be used to treat heart disease was included (Miller and Levine, 2015, p. 296). Students are prompted to think about the biases and misinformation of stem cell research in various forms of media. There is a section titled, "Heart Disease and Treatment," which discusses risk factors such as smoking, obesity, excess alcohol intake, and dietary choices in high cholesterol and high blood pressure (Miller and Levine, 2015, p. 799). The section does not discuss the issue of access and that people of color from areas of

low-SES are less likely to receive preventative and active treatments associated with heart disease.

This textbook did not contain any specific section on sexual health or sexually transmitted diseases. There was no mention of syphilis, gonorrhea, or chlamydia. It did discuss sexual health in the context of HIV and included the following statement, "The best ways to avoid HIV infection are abstinence from sexual activity and avoidance of illegal intravenous drug use (Miller and Levine, 2015, p. 899)." There was no discussion of the importance of condom use or STD testing if sexually active, nor where to access these resources. There was also no discussion of preventative measures that can be taken to reduce contraction of STDs (Kraig-Turner, 2016).

Environmental literacy

This text does contain information regarding climate science consensus. It prompts students to address misconceptions regarding climate versus weather and how climate is very predictable. While it does include a section on climate change, it does not require students to discuss climate change denial and how certain groups are more impacted by negative effects of climate and industrial pollution. It does mention how burning fossil fuels can alter the carbon cycle. The section contained images associated with representations of overfishing, deforestation, and factories pumping gasses into the air.

The text defines pollution and mentions how industrial and agricultural chemicals impact the air and water. However, it does not require students to discuss how this may have a direct impact on them, except for stating, "if you live in a large city, you have probably seen smog (Miller and Levine, 2015, p. 163)." It states that pollutants can "threaten human health, especially for people with respiratory conditions (Miller and Levine, 2015, p. 163)." It does not mention the fact that it is often people of color in communities of low-SES that are disproportionally impacted by pollution and how industries that pollute are seldom held accountable.

The textbook discussed the fact that average U.S. citizens have a higher ecological footprint compared to other countries. It is not organized in a way that enables students to think of ways they can reduce their ecological footprint and how they can make more mindful decisions, such as not littering, keeping lights off, buying thrift clothing, and using public transit. The textbook mentioned "cultures" and the impact of ecological footprint but does not go into much detail. It does have a three-step research process (1) recognizing the problem, (2) researching the cause, (3) changing behavior and compares it to a case study but does not require students to apply this to their lives, thereby missing an opportunity to increase literacies.

Multiculturalism

Regarding race, this textbook provides very little explicit statements regarding race. As described in the health literacy section, there was a brief statement on the impacts heart disease can have on the African American community. This textbook does cover body systems, although they are discussed in a single chapter. Diagrams and figures of humans were largely white male representations or outlines with no associated color. However, there was a figure of the respiratory system that had an African American female (Miller and Levine, 2015, p. 877). In addition, there was also a figure showing the organization of human muscle in an African American male (Miller and Levine, 2015, p. 885). The main historical figures such as Watson & Crick, Robert Hooke, and Louis Pasteur were mentioned in the text, having very detailed sections regarding their contributions and histories while excluding scientists from traditionally marginalized groups. The textbook contains diverse scientists scattered throughout the text in a "Career Highlights" section but none of the profiles explicitly state anything regarding their identity (e.g., gender & race).

Regarding gender, the textbook does mention Rosalind Franklin's contribution to the discovery of DNA, although the textbook does not mention the adversity she endured. It is also not mentioned that Watson and Crick published Franklin's image without her consent, which is an act of plagiarism, something heavily discouraged in science. There is no mention of Henrietta Lacks in this textbook.

The textbook contained sections on "Differentiated Instruction" section to address special needs students (e.g., visually impaired) and English Language Learners (ELLs). There were additional sections to help educators differentiate between "Less proficient readers" and "advanced students." There were also sections that helped educators to focus on "Struggling students." The textbook does have pictures of students of color performing activities, but this would be considered an additive approach. It does not explicitly state why it is necessary to include such representations in the textbook.

McGraw Hill textbook

Scientific literacy

There was no specific statement on scientific literacy. Like the other textbooks, there were sections related to "Real-World Connections," addressing English Language Learners, and addressing misconceptions, although the examples were not relevant to the lived experiences of students.

Health literacy

This textbook had a very comprehensive section on nutrition. It required students to think of how nutrition is applied to their own lives. Students are asked to consider saturated fats and high carbohydrate diets and to research a particular disease. There is a quote that states, "A diet high in saturated fats might result in high blood levels of cholesterol, which can lead to heart problems (Biggs et al., 2015, p. 1026)," but it does not go beyond that in terms of describing the impacts on communities of color in areas of Low-SES. Students are instructed to create a record of what they consume during the week, making it relevant to their lived experiences. It asks them to examine nutrition labels to determine serving size and nutrient value of carbohydrates, fats, proteins, vitamins, and minerals (Biggs et al., 2015, p. 1027), which intersects with scientific literacy. There is a section that asks students to bring in a food advertisement from a newspaper or magazine and to assess whether the claim being made is healthy or not. It also has students think of misconceptions on food label packaging (Biggs et al., 2015, p. 1028). It did contain a real-world connection regarding rising obesity rates (Biggs et al., 2015, p. 1029). Further, it asks students to write an article of what a well-balanced diet looks like (Biggs et al., 2015, p. 1030). It did not mention that unhealthy foods tend to be highly accessible in such communities, contributing to the development of chronic illness. The text describes Type II diabetes as a condition where, "the pancreas does not make the proper amount of insulin and glucose does not enter body cells normally… (Biggs et al., 2015, p. 1093)." In the same section it further states that type II diabetes, "[…] can have a genetic component but

also can involve environmental factors such as diet." It does so without mentioning the fact that type II diabetes has a disproportionate impact on communities of color in areas of low-SES. The section of the textbook covering the cardiovascular system does not mention heart disease, heart attacks, or cardiac arrest. It solely focuses on the heart from a functional aspect.

There is content surrounding sexual health and sexually transmitted diseases. A table was included that had syphilis, gonorrhea, and chlamydia listed in a sexually transmitted diseases category, although it was not descriptive. There was no statement on abstinence in the prevention of STDs. In fact, the textbook largely avoided the discussion of sexual intercourse. There was no mention of condom use or STD testing, nor where to access these resources. The statement, "current antiviral drug therapy is aimed at controlling the replication of HIV in the body (Biggs et al., 2015, p. 1091)," does not include modern treatments/prevention, such as pre-exposure prophlaxis (PREP). There is a "Integrate History" section that discusses the Bubonic Plague and an "Integrate Health" section that discusses syphilis infection and treatment. There was a missed opportunity to discuss the historical context of syphilis in the United States related to the Tuskegee Syphilis Experiment and the poor public health response to the HIV epidemic (Kraig-Turner, 2016).

Environmental literacy

Unlike the other two texts, this did not have detailed sections regarding the impact the fossil fuel and agricultural industries have on the environment. In addition, there were no images of factories churning smoke into the air. The closest thing presented in the text was an image representing deforestation. It did include sections that address pollution, and the impacts humans can have on the environment, but it does not mention how communities of color in areas of low-SES are disproportionally impacted. It does not require students to think of their behaviors and the impact they can have on the environment.

The textbook detailed the destruction of natural habitats that can result in extinction of certain animals. There were no prompts encouraging students to think about how we can create solutions for these issues. There was a section describing a story where community perception of bats in Austin, Texas was changed, placing the curriculum in a local context.

Regarding climate change, the textbook did prompt students to think of, "ways humans might be affecting climate (Biggs et al., 2015, p. 66)," suggesting that there is not a strong scientific consensus regarding our impact on the climate. There was not much information regarding the ecological footprint that the U.S. has compared to the rest of the world.

The textbook did include a section on Genetically Modified Organisms (GMOs). It requires the students to discuss the pros and cons associated with the use of GMOs. It states, GMOs have many benefits, but have political, social, and economic implications that impact agricultural production. It does not mention how the use of GMOs can potentially help to reduce costs and feed people in developing countries. It also does not expand on the misinformation regarding GMOs and food irradiation.

Multiculturalism

Regarding race, this textbook did not provide explicit statements. Diagrams and figures of human male and female anatomy from various body systems were representations of white bodies. There was one figure of the internal and external ear that featured darker pigmentation. Discusses local context (Biggs et al., 2015, p. 82).

Regarding gender, there was a mention of Rosalind Franklin and an image of her famous photo 51, although there was no picture of her. It was mentioned that the photo helped Watson and Crick without mentioning the fact that they took the image and published it without her consent. There was also no discussion of the sexism and misogyny Franklin faced (Biggs et al., 2015, p. 330). Henrietta Lacks is not mentioned in this textbook.

The textbook contained a differentiated instruction section for ELLs, for below level students, and for the visually impaired (Biggs et al., 2015, p. 194). There were pictures of students of color performing activities, but this would be considered an additive approach. It does not explicitly state why it is necessary to include such representations in the textbook.

Discussion

While standards themselves and the idea of standardizing knowledge can be problematic (Karp, 2013), the authors are not debating whether there should be science standards in this work. Instead, the authors are critically examining the standards and textbooks as they exist to identify the ways that relevancy as described in the previously discussed literacies and multiculturalism are included or excluded from the "official curriculum." The elements presented in the textbooks were not supportive enough to truly develop scientific literacy, health literacy, environmental literacy, and multicultural awareness. Overall, the textbooks provided some additive opportunities to connect scientific content to relevancy and multiculturalism but failed to have enough additions to warrant a Level 1 rating. The authors instead settled on "approaching level 1" and scored these texts as a 0.5 (see Table 2). No content presented in any of the textbooks reached levels of being Transformative or Social Action.

When the textbooks made attempts at including relevant concepts, the content was presented in a fact-oriented way, emphasizing key terms in bold print and figures rather than helping students think deeper about the rationale or "why" behind the topic. There also seems to be an expectation for teachers to possess a high level of knowledge to draw important connections between science and society. The burden of making these concepts relevant then falls on the teachers, rather than the curriculum providing some support and placing value on relevancy. One major concern from this critical examination of standards and textbooks is that the explicit inclusion of multiculturalism and meaningful relevancy is rare or nonexistent.

A common trend for all three texts was the placement of chapters dedicated to health. All three textbooks had weak general discussions of ecological principles. This analysis illustrates that minor efforts have been made by publishers to include more diverse content in a non-additive manner and make attempts at promoting relevancy related to the three literacies. The weak additive nature of these adjustments to the curriculum are poorly executed, revealing that the publishers know that relevancy and multiculturalism are real issues that need to be addressed.

Each textbook had different interpretations of the TEKS Biology Standards, highlighting the fact that the standards do not streamline

TABLE 2 Consensus ratings for relevancy and multiculturalism in standards and textbooks.

Standards	Relevancy			Multiculturalism			
	Scientific Literacy	Health Literacy	Environmental Literacy	Race	Gender	SES	Sexuality
	0.5	0.5	0.5	0	0	0	0
Textbook							
Houghton	0.5	0.5	0.5	0.5	0.5	0	0
McGraw Hill	0.5	0.5	0.5	0.5	0.5	0	0
Pearson	0.5	0.5	0.5	0.5	0.5	0	0

Level 0 – Absence, Level 1 – Additive, Level 2 – Transformative, 3- Social Action.

the textbook production process. Some textbooks did more than others relating to the inclusion of nutrition, history, lived experience, and the environment. A specific example is present in sections discussing sexual health and sexually transmitted diseases (STDs). The Pearson textbook does not include a section on STDs while the McGraw Hill and Houghton, Mifflin, & Harcourt contain comprehensive sections. This could be due to Texas politically taking issue with STDs being discussed in science classrooms despite being directly related to scientific, health, and environmental literacy.

There were major differences in how the fossil fuel industry is portrayed within the textbooks. Two of the textbooks included images depicting the fossil fuel industry in a negative light and explicitly stated the impact these industries have on the environment. There were also differences in how students should think about the impact these industries and how their lives can be negatively impacted. There was variation in presentation of topics like GMOs. Two textbooks discussed GMOs while one did not mention GMOs at all.

Interestingly, the textbooks modeled their activities using wording taken directly from the TEKS Biology Standards. For example, an activity from the Pearson Biology Textbook stated, "How is scientific literacy important when evaluating promotional materials (p. 914)?" The TEKS Biology Standards states that students shall be able to, "draw inferences based on data related to promotional materials for products and services (c)(3)(C)." This reveals the power the TEKS Biology Standards has on shaping the language and content included in biology textbooks. It also appears statements such as, "analyze the importance and benefits of abstinence as it relates to emotional health and the prevention of pregnancy and sexually transmitted diseases," present in the TEKS Health Education Standards has an influence on the structure of the biology textbooks, given the drastic differences across textbooks regarding sexual health.

The textbooks all included images of people of color engaging in activities and featured scientists from diverse backgrounds. Such representations are important for students from traditionally marginalized groups so they can see themselves represented in the curricular materials. While this is a great start, these efforts are still additive, therefore, more must be done to promote engagement in science. There needs to be descriptions as to why these diverse representations are included to narrow the STEM gap, encourage participation in medical studies, and to reduce prejudice/racism.

Multicultural efforts should stretch beyond a celebratory month or single point in time to avoid being reduced to heroes and holidays. By making standards and textbooks more transformative and social action oriented, core curriculum for all science students would be improved, and not simply available to some, particularly those with more access to resources.

Considering the obvious deficiencies present within state standards and the textbook formulation in response to these standards, it is vital for science educators to further investigate the impact standards and textbooks have on scientific understanding in society. It is also important for teachers and students to understand the hidden curriculum to help them successfully navigate the academic landscape and avoid pitfalls experienced by those who are unaware of its influence (Winter and Cotton, 2012; Milks, 2021).

Nearly all textbooks consist of recycled material that is often uninspiring and not relevant to society (Budiansky, 2001). The textbooks analyzed give this sense of having the core material remaining largely unchanged over the years, with only minor updates or additions to make them more contemporary. Publishers could alter the content of their textbooks to meaningfully include aspects of relevancy and multiculturalism, yet it is unlikely they would do so without states making modifications to existing standards that would require these changes.

The content of textbooks and the standards that guide their production are closely observed by a socially diverse list of stakeholders, resulting in a perpetual political tug of war over curriculum. Texas is a state where local districts select textbooks from an approved adoption list. Unfortunately, many publishing companies sacrifice content to avoid rejection from the list to increase profits. The standardization of material can also be potentially contradicting to students' realities, promote eurocentrism, and reinforce the boundaries that prevent traditionally underrepresented groups from actively holding stake in the scientific community (Atwater, 2010).

State autonomy to determine standards can result in the exclusion of content that is essential to promoting scientific literacy, health literacy, environmental literacy, and multicultural science education awareness. Absence of these literacies are perhaps indicated by lack of awareness of basic environmental issues, reemergence of anti-vaccination movements, climate change denial, and increases in poor population health (Coyle, 2005; Dunlap and McCright, 2010; Kata, 2010; Stanger-Hall and Hall, 2011). For example, Texans continue to be diagnosed with a multitude of largely preventable chronic health issues such as heart disease, obesity, and diabetes, yet the standards continue to promote a curriculum grounded in rote memorization of discrete facts that fail to prepare students to make informed health decisions. These issues mainly manifest in underserved, low-income areas consisting of traditionally marginalized racial groups. Recent events such as the impact of COVID-19 in communities of color in areas of low-SES, the water crisis in Flint, MI, and the impact of more powerful weather events, such as the hurricanes in 2017 and snowstorms of 2021, are all rich opportunities to connect scientific thinking, critical decision making, and connecting science to society.

TABLE 3 Opportunities to implement transformative and social action approaches into biology standards and textbooks to promote relevancy and multiculturalism.

Biology standards
Scientific literacy • Standards can be more explicit regarding critical thinking and problem solving as it relates to real world issues pertaining to sociodemographic factors, allowing students to scaffold their knowledge and draw meaningful connections (Level 2). • Include a section that requires students to differentiate between reliable information and misinformation (Level 2). • Require students to apply critical thinking and problem solving when using technology to navigate the internet (e.g., social media website, promotional websites) (Level 2). • Require students to develop the skills necessary to objectively refute false claims (Level 2).
Health literacy • Require students to understand and describe the links between disease and sociodemographic factors. • Require students to understand describe how biomolecules relate to their daily life, such as in the interpretation of a nutrition label, and how these biomolecules relate to the prevention and development of chronic illnesses. • Require students to describe the impact of microorganisms on risk of disease transmission among vulnerable populations (Level 2).
Environmental literacy • Require students to understand and describe the links between disease and socioenvironmental factors (Level 2). • Require students to understand how industries can be responsible for the disruption of ecosystems, often to the detriment of humans and other organisms (Level 2).
Multiculturalism • Require the students to research and describe the various cultural histories of biology (Level 2). • Require students to research and describe the contribution of scientists from a variety of backgrounds, highlighting the overcoming of adversity (Level 2).
Biology textbooks
Scientific literacy • Include definitions of scientific literacy and explain how developing critical thinking and problem-solving skills can help students to better understand the complex link between science and society. • Include "Real-World Connections" sections in the textbook that are relevant to the lived experiences of the students, drawing connections between science and perspectives of diverse communities (Level 2). • Include a prompt that requires students to identify scientific misinformation presented in various formats and to launch a media campaign aimed at providing rebuttals to educate the public (Level 3).
Health literacy • Include "Health Connections" sections that are relevant to the lived experiences of students, drawing connections between science and perspectives of diverse communities. • When discussing chronic diseases, have students reflect and discuss the disproportionate impact on marginalized communities (Level 2). • Include prompts that require students to gather population health statistics from local health departments, enabling them to understand issues impacting their community (Level 2).
Environmental literacy • Include sections that discuss events in which industries polluted the environment and the risks of future events, stressing accountability, environmental regulation, and the importance of students engaging civically (Level 2). • Include sections that encourage students to contact their local, state, or national representative regarding a specific environmental issue (Level 3). • Include sections that allow students to link sociodemographic factors and the risk of developing diseases resulting from exposure to pollutants (Level 2).
Multiculturalism • Be intentional about the inclusion of cultural aspects, overcoming adversity, and persevering in the field of science when including "Career Highlights" sections in the textbooks. (Level 2). • Include discussion/research prompts that allow the students to link biology topics, such as the development of chronic illness, to sociodemographic factors (Level 2). • Encourage students to be more proactive in disease prevention through dissemination of public health information to their families and community (Level 3). • Explicitly state commitment to Diversity, Equity, and Inclusion (DEI) and belonging efforts. Highlight inclusion of students and scientists from diverse background and the link between biology topics and sociodemographic factors featured in the textbook (level 2).

While many students meet the requirements for successful completion of their science courses, they often leave without retaining scientific ideas and are presented with concepts they are unlikely to encounter in the real world. There is a need to reevaluate how we approach teaching and learning biology in our schools. This means we must be critical of the curricular materials present within the classroom and uncover the invisible barriers responsible for maintaining inequities. We must also be critical of the biology standards that drive the production of curricular materials.

We must ensure standards are linguistically constructed to generate an official curriculum that will equip students with the knowledge necessary to improve their lives. Political matters in science education should be deeply embedded within standards and the curricular materials produced from them. With such drastic shifts in access to information via technology, it is also vital students develop scientific literacy to understand how to navigate various forms of media, evaluate data sources, and objectively form conclusions rather than being solely influenced by ideology. In an ever-evolving information age where websites are fraught with misinformation that can be detrimental to society, it is important for students develop these competencies.

Despite the importance of discussing and understanding issues related to race, recent trends of media misinterpreting Diversity, Equity, and Inclusion (DEI) initiatives and encouraging elected school board officials to implement policies that would prevent discussions of issues surrounding race is particularly concerning. Such trends may lead to stalling of initiatives to promote multicultural awareness in classrooms. Administrators and teachers may be more fearful of promoting aspects of relevancy and multiculturalism due to fear of backlash and possible termination. In a time where topics surrounding race, gender, and sexuality are viewed as controversial, it may be more likely that textbook publishers will be reluctant to highlight these aspects when developing new editions. Given the value and importance of narrowing the STEM gap, stakeholders in science education must continue to fight for a meaningful and just curricular framework. Only then will science truly be for all.

In effort to be solution oriented, potential opportunities to enrich standards and textbooks (Table 3) are presented through the transformative approach and social action approach, placing emphasis on relevancy and multiculturalism. It must be stated that the intention of this work is not to replace the existing curricular framework, but to enrich it.

Implications for future work

While standards and textbooks provide a basic curriculum, there is also a need to see how these elements are presented in the classroom. It would be valuable to speak to biology teachers and observe in biology classrooms to better understand how relevancy and multiculturalism manifest in classroom settings. Understanding teachers' thoughts and curricular decision making around a need for more relevant or multicultural connections in biology would also be meaningful.

Limitations

The examination only involved two coders and was limited to three Texas textbooks. Other adopted textbooks may or may not contain the same issues. After a recent TEKS Biology review, no significant changes were made, meaning it is likely no content alterations will occur. However, it is possible that new editions may address some issues presented in this work. While not the prevailing methodology in this study, it must be acknowledged that Multicultural Education and the Levels of Integration of Multicultural Content contain many parallels to Critical Theory. Limitations of Critical Theory include ideological biases and a reliance on subjective values that shaped the development of the proposed curricular transformation presented in this paper.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SV and EA participated in drafting the literature review for the manuscript, development of the coding scheme, analysis of the textbooks, and coding consensus. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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