

Who Gets to Belong in Chemistry? A Decolonization Perspective Informed by Dominant Group Theory

Zakiya S. Wilson-Kennedy ^{1,2,*}, Raeshan D. Davis ³ and Christen D. Jones ¹

¹ Department of Chemistry, Louisiana State University, Baton Rouge, LA 70803, USA; cjon435@lsu.edu

² College of Science, Louisiana State University, Baton Rouge, LA 70803, USA

³ College of Arts & Sciences, The Ohio State University, Columbus, OH 43210, USA; davis.7832@osu.edu

* Correspondence: zwilson@lsu.edu

Abstract

A sense of belonging in science, technology, engineering, and mathematics (STEM) education is often conceptualized primarily through social dimensions, overlooking its disciplinary and epistemological contexts. In chemistry, understanding belonging requires examining how disciplinary culture, values, and norms shape who feels included and who is excluded. This perspective article explores belonging in chemistry (a STEM discipline) as a multidimensional construct, emphasizing the intersections of social, cultural, and epistemic dimensions that influence students' participation and identity development in chemistry. Through a critical synthesis of literature informed by dominant group theory and decolonization frameworks, this work interrogates how Eurocentric definitions of merit and excellence perpetuate exclusionary practices and constrain the belonging of nondominant groups. The analysis identifies key opportunities in chemistry to support the participation of all and offers asset-based considerations for transforming departmental and instructional practices. We conclude that advancing belonging in chemistry requires reexamining disciplinary norms and adopting new approaches that validate multiple ways of knowing and contributing to the chemical sciences.

Keywords: belonging; dominant group theory; STEM education; reflection

1. Introduction

Belonging has significant implications for student success in higher education (Covarrubias, 2024; Li & Singh, 2023; Meehan & Howells, 2019; Ménard et al., 2024; Ravishankar et al., 2024). Scholars define belonging as “a fundamental human need and a basic right” (Strayhorn, 2018), encompassing an individual's perception of being welcomed, accepted, and included within a community or space (Covarrubias, 2024; Strayhorn, 2018). Covarrubias characterizes belonging as an intimate emotion bound by intersecting social influences that aim to encompass and exclude different social realities (Covarrubias, 2024). Strayhorn suggests that one's sense of belonging in educational spaces exists “where group members are significant to each other, and the group is affirmed, mirrored, and conveyed through a network of institutional policies, programs, and practices that clearly express that you are wanted, valued, and accepted within this space” (Strayhorn, 2018). It is shaped by various interconnected factors, e.g., individual identity, familial and societal heritage, interpersonal relationships, and the contextual

Academic Editors: Amber Simpson,
Antonio-Manuel Rodríguez-García
and Juan Carlos de la Cruz-Campos

Received: 31 October 2025

Revised: 14 December 2025

Accepted: 27 January 2026

Published: 3 February 2026

Copyright: © 2026 by the authors.
Licensee MDPI, Basel, Switzerland.
This article is an open access article
distributed under the terms and
conditions of the [Creative Commons
Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

impact of one's environment (Covarrubias, 2024; Freeman & Ortiz, 2019; Gopalan & Brady, 2020; Gravett & Ajjawi, 2022).

Empirical research has sought to explain belonging and the ways in which perceptions of belonging influence persistence in educational contexts (Hansen et al., 2023; Kirby & Thomas, 2022; Li & Singh, 2023; A. L. Miller et al., 2019; Strayhorn, 2018). For instance, findings suggest that fostering a sense of belonging among students is crucial for their academic success and overall well-being within educational settings (Allen et al., 2024; Clements et al., 2022; Freeman & Ortiz, 2019; Hansen et al., 2023). Conversely, negative sociocultural cues can influence the academic success of students, including high academic achievers (Bayar & Karaduman, 2021; Good et al., 2012). As an example, studies have shown that despite strong academic performance, students from non-dominant groups in the U.S., experience disproportionate levels of attrition in science, technology, engineering, and mathematics (STEM) disciplines (Harris, 2019; Hays, 2008; Song et al., 2020; Thiry et al., 2019). This attrition occurs even when controlling for academic preparedness, suggesting that sociocultural cues, such as belonging, involve more than academic competence alone (Harris, 2019; Hays, 2008; Song et al., 2020; Thiry et al., 2019).

Moreover, studies have demonstrated that culturally relevant engagement and targeted support programs and initiatives can enable students to persist by helping them to see themselves as valued members of the academic and scientific community (Yabang et al., 2025). For example, Indigenous students in biomedical sciences and related fields were more likely to persist based on access to support structures that positively impact belonging factors. Herein, critical financial support, targeted fellowships, and scholarship programs provide dedicated safe spaces, mentoring, and a grounded acknowledgement of Indigenous ways of knowing that help to build confidence and spark career aspirations and intentions (Yabang et al., 2025). Broader findings suggest that culturally responsive educational programs positively influence Indigenous students' science identity and engagement by validating their cultural background and ways of knowing (Jin, 2021).

The implications for chemistry are clear. Fostering a sense of belonging in chemistry, through affirmation of identity, cultural relevance, and mentoring, can be a critical lever in advancing the participation and success of all students in our discipline. Belonging is especially important in chemistry because high-impact learning environments provide the conditions for all learners to engage, persist, and thrive, regardless of background (Graulich et al., 2023). These findings underscore the significant importance and impact of belonging in chemistry education on student engagement, academic success, and overall sense of validation within the scholarly community.

Dominant Group Culture Impacts Belonging and Merit for Non-Dominant Groups

The current discourse on belonging in higher education often focuses on social integration within the college environment (Freeman & Ortiz, 2019; Ménard et al., 2024; Strayhorn, 2018; Tellhed et al., 2017). While important, this focus on the social foundations of belonging overlooks the unique contexts that shape chemistry training and culture. In STEM learning environments, especially within the U.S., belonging is not solely about social connections but is deeply influenced by perceptions of merit, scientific knowledge, performance, and recognition (Belanger et al., 2020; Carlone & Johnson, 2007; Kim & Sinatra, 2018; Kim et al., 2018). This focus on academic competence and validation of that competence creates additional dimensions of complexity for students, especially for potentially vulnerable populations who may feel marginalized despite demonstrating academic ability (Allen, 2025). Herein, the concept of dominant group culture can help to explicate this phenomenon (Adejumo, 2021).

Dominant group culture significantly shapes the merit-based ideologies that influence belonging by defining what is considered legitimate knowledge, valid

accomplishments, and valued intellectual contributions (Adejumo, 2021; Carter & Welner, 2013; Delpit, 2006; Patel, 2015; Yosso, 2005). By privileging their language, education, institutions, social standards, etc., dominant groups set implicit and explicit cultural norms and systems that are often biased toward the majority identities (Apple & Apple, 2004; Bourdieu, 1991; Delpit, 2006; Yosso, 2005). This has the potential to negatively affect non-dominant groups by failing to validate their knowledge and sending subtle sociocultural cues that suggest they do not belong.

The dominant group culture is inherently connected to colonization because colonial power structures historically elevated their dominant groups, while erasing or marginalizing non-dominant groups, identities, and cultures (Quijano, 2000; Tuhiwai Smith, 2012), whether intentionally or non-intentionally. We note that dominant group membership may be generalized by a number of identifying factors, including gender, economic class (affluent/low-income), geographic location (rural, urban, suburban), race and ethnicity, ableness (disabled, able-bodied, neurodivergent), and others. Dominant group theory posits that dominance is not simply a result of having a demographic majority but about controlling a 'community's resources, norms, and institutions by shaping laws, policies, education, media, and cultural values (Razzante & Orbe, 2018). Herein, dominant groups frequently expect non-dominant groups to assimilate and suppress their own cultural expressions or identity markers, which often reinforces inequities (Hooks, 2014; Tatum, 2017). Given that dominant group culture establishes implicit and explicit criteria for defining "merit" and that there is significant evidence that belonging intersects deeply with notions of merit and academic validation, addressing the critical impacts of dominant culture on chemistry learning environments necessitates an approach that deeply acknowledges dominant group culture and its resulting consequences for non-dominant groups.

Our perspective article features an analysis that explores how decolonizing belonging, or more specifically, acknowledging the impacts of dominant culture on non-dominant groups, can support efforts to broaden the participation of all in chemistry. The purpose of this analysis is to illuminate how systemic structures, societal norms, and dominant group ideologies shape students' experiences of belonging in chemistry, particularly by identifying and understanding the factors that either foster or hinder a sense of belonging among non-dominant groups and potentially vulnerable populations. We will examine the = systematic structures that influence belonging in chemistry, considering how they intersect with issues of dominant/non-dominant group dynamics of power, privilege, and exclusion. Emerging from this analysis, we offer practical recommendations for creating high-quality learning environments that support all students, particularly those from non-dominant groups. This analysis is positioned as a starting point to challenge the current status quo in chemistry education, acknowledging that decolonizing belonging is a multifaceted and systemic challenge that requires the sustained, collective efforts from educators, policymakers, and academic institutions to transform chemistry environments into spaces where all students belong, experiencing both validation and support. Notably, faculty have the opportunity to foster belonging in their classrooms and spheres of influence.

2. Decolonizing Belonging: Insights from Dominant Group Theory

Decolonization refers to the process of overcoming dominant group culture by challenging and dismantling structures, epistemologies, and practices that have historically shaped and controlled academic spaces (Gjøvik, 2025). It involves rethinking the Western-centric frameworks of knowledge production and integrating "othered"" (Kumashiro, 2000; Shahjahan et al., 2022), often marginalized, perspectives, cultures, and methodologies (Gichuru, 2024; O'Neill et al., 2023). This process could include revising curricula to incorporate Indigenous knowledge systems, promoting more inclusive research agendas,

and fostering equitable representation within the academy (Gichuru, 2024). Decolonization also requires addressing systemic inequalities within academic institutions, ensuring that all have greater access, support, and opportunity (Gjøvik, 2025; O'Neill et al., 2023; Stein & Andreotti, 2016). By challenging the legacies of colonial dominant group influence on scientific practices, decolonization aims to create a more utopian environment wherein all voices are heard and valued, and opportunity gaps are alleviated (Cicek et al., 2023; de Sousa Santos et al., 2016; Stein & Andreotti, 2016).

This focus on decolonization becomes especially important when considering the significance of belonging in chemistry higher education. In recent years, efforts to increase participation in chemistry for all have gained momentum (Burke et al., 2022; Dasgupta & Stout, 2014; National Center for Science and Engineering Statistics (NCSES), 2023; Wilson-Kennedy et al., 2020, 2022) and necessitated a deeper understanding of how our systems impact all populations. Traditional dogmas in chemistry often tie belonging to scientific competence and performance, suggesting that individuals who excel in their field are more likely to feel a sense of belonging. However, despite demonstrating proficiency, non-dominant groups are more likely to experience a lack of recognition and validation, resulting in a diminished sense of belonging (Brockman, 2021; Good et al., 2012; Tellhed et al., 2017). Applying dominant group theory as a critical lens, the relationship between merit and belonging can be materialized through systemic barriers, which create environments that are not welcoming of non-dominant groups in chemistry (Dortch & Patel, 2017; Jackson, 2016; Ménard et al., 2024; Ovink et al., 2024; Rodriguez & Blaney, 2021; Taylor & Turk, 2019; Williams et al., 2014).

To broaden participation in chemistry for non-dominant groups, it is essential to shift toward a new understanding and approach to fostering belonging (Shahjahan et al., 2022). In practice, decolonizing belonging would challenge and intentionally dismantle colonial dominant group structures and epistemologies, and intentionally integrate non-dominant, often marginalized perspectives (Gichuru, 2024; O'Neill et al., 2023).

3. Exploring Belonging in Chemistry as a Multidimensional Construct

Belonging in chemistry is deeply influenced by dominant cultural norms and merit-based ideologies (Gilani et al., 2024). Given that dominant groups define what is valued as scientific competence and performance, often marginalizing non-dominant groups (Bhopal, 2020; Kozlowski et al., 2022; McCabe, 2009; Morton & Nkrumah, 2021), if we seek to create learning environments that are welcoming for all, we must interrogate our mental models of belonging.

3.1. *Belonging and Persistence*

A comprehensive review of the literature on belonging reveals that scholars have collectively defined it as a deeply rooted sense of being genuinely valued, accepted, and recognized as an integral member of a group (Baumeister & Leary, 2017; Fong et al., 2024; Gopalan & Brady, 2020; Maslow, 1943; Strayhorn, 2018). One of the earlier frameworks, Tinto's Theory of Student Departure, has played a pivotal role in shaping our understanding of student integration and student persistence in learning spaces (Tinto, 1987, 1993). Building upon this concept, Hurtado and Carter further advanced the understanding of belonging in learning spaces, positing that community membership is essential for fostering a sense of belonging (Hurtado & Carter, 1997). Grounded in these foundational assumptions about belonging, the work of Strayhorn further contributes to our understanding of this complex and multifaceted concept of belonging. His model on College Students' Sense of Belonging illustrates the intricate relationship between fundamental human needs and the presence of nurturing and supportive environments as crucial components of an individual's sense of belonging (Strayhorn, 2018). Furthermore, this

conceptual framework underscores the multifaceted nature of belonging, illustrating how it can be influenced by a wide range of factors, including one's diverse identities, the social contexts in which they exist, and the specific circumstances that manifest within educational environments.

3.2. *Belonging as Capital*

An essential component of an individual's feeling of acceptance and inclusion within a particular social group or community is their ability to navigate the customs, values, and behaviors of that specific culture. Bourdieu theorized that an individual's participation and sense of belonging in social settings are primarily influenced by the possession of cultural capital (Bourdieu, 1986). Cultural capital encompasses various elements, including education and language, social connections and memberships, financial resources, and material possessions (Bourdieu, 1986; Tilbrook & Shifrer, 2022).

Bourdieu's theory suggests that powerful societal groups maintain their advantage by controlling access to different forms of capital, such as economic, social, and cultural resources. While Bourdieu's theory of cultural capital has been widely used to analyze differences between sub-populations, it is important to recognize that this perspective may unfairly exclude certain groups because they lack traditional forms of capital (Kingston, 2001; Lamont & Lareau, 1988; Sullivan, 2002; Yosso, 2005). This approach often views these groups from a deficit standpoint and fails to acknowledge the value and significance of the capital that non-dominant groups possess, thus perpetuating a cycle of inequality and disadvantage that results in marginalization. Social capital and belonging are intricately tied, and intergroup dynamics play an important role in understanding this phenomenon.

3.3. *Belonging and Science Identity*

To deepen the understanding of belonging in chemistry, the Science Identity model provides a valuable framework, highlighting three interconnected factors (i.e., competence, performance, and recognition) influencing an individual's sense of belonging in science spaces. Competence refers to an individual's understanding of chemistry content matter (Carlone & Johnson, 2007). Performance entails the active demonstration and application of scientific knowledge and expertise; more specifically, it is defined by an individual's ability to use chemistry knowledge (competence) in diverse settings, including laboratory, classroom, and other professional spaces (Carlone & Johnson, 2007). Recognition is the acknowledgment and validation of an individual's competence and performance within the chemistry community (Carlone & Johnson, 2007; Sandrone, 2022). These factors interact dynamically, each influencing the others in shaping an individual's science identity development. Within this model, the assumption is that as individuals demonstrate their competence in chemistry content, perform their disciplinary knowledge, and receive recognition through merit for their competence and performance, their science/chemistry identity is strengthened, ultimately leading to an increased sense of belonging in the chemistry community.

3.4. *Belonging and Dominant Group Theory*

While science identity is framed as a neutral concept of belonging, the systems and practices shaping it within learning environments can be biased and exclusionary. Previous research on chemistry culture, contexts, and learning environments consistently shows that a sense of belonging is heavily influenced by the norms of the dominant societal groups in discipline culture (Bhopal, 2020; Kozlowski et al., 2022; McCabe, 2009; Morton & Nkrumah, 2021). Eurocentric perspectives and knowledge systems have significantly influenced the norms and culture within chemistry. Non-European (and non-

Western) identities, scientific knowledge, and contributions are frequently disregarded, especially when deemed to be misaligned with the dominant culture (Allen et al., 2021; Philip & Azevedo, 2017). As an example, a deliberate omission of scientific insights and practices from Indigenous cultures within the dominant Western scientific framework is a significant consequence of the dominance of Eurocentric ideologies (Philip & Azevedo, 2017; Pokhrel, 2011). Such exclusion perpetuates inequality in both the recognition and dissemination of knowledge, hindering the advancement of diverse identities and perspectives in scientific discourse.

Longstanding biases in academia continue to equate scientific excellence with Western institutions, thereby limiting the visibility and valuation of diverse contributions (Khalid & Ting, 2025). As an example, there are many instances when researchers from more privileged, high-income countries conduct studies in less privileged, lower-income regions without meaningful engagement or collaboration with local scholars (Adame, 2021; Asase et al., 2022; Odeny & Bosurgi, 2022; Roldan-Hernandez et al., 2020; Stefanoudis et al., 2021). These types of “helicopter research” and “parachute” scientific practices marginalize researchers from less privileged groups by excluding their epistemologies (Lambert et al., 2024; Stefanoudis et al., 2021), thereby reinforcing privileged and dominant group frameworks of knowledge production (Gjøvik, 2025). This structural imbalance not only undermines capacity-building in under-resourced regions but also perpetuates systemic inequities in authorship, recognition, and scientific legitimacy. These exclusionary practices are sustained by unequal power dynamics and institutional norms that systematically “other” non-Western scholars and communities (Fluit et al., 2024).

4. Who Belongs in Chemistry?

Learning environments often embrace merit-based structures as a means of stratifying individuals. The concept of merit refers to the idea that individuals are recognized and rewarded based on their qualities and actions (Blair-Loy & Cech, 2022). In chemistry, merit often plays a prominent role in shaping the experiences of individuals based on their ability to obtain recognition for their work (Blickenstaff, 2005; Duncan & Zeng, 2005). Merit encompasses various aspects, including but not limited to, increased financial support, access to highly sought-after professional opportunities, and inclusion within the broader scientific community (Blair-Loy & Cech, 2022; Roithmayr, 1998; Walker et al., 2010). Therefore, acquiring merit not only validates an individual’s standing within their scientific community but also serves as a signal of belonging and acceptance. The question we ask is who determines the criteria for merit within our discipline, and do these criteria privilege some and disenfranchise others?

Previous scholarly research has extensively highlighted pervasive systemic inequities and biased environments in chemistry higher education, shedding light on the barriers that hinder the success and acknowledgment of individuals from non-dominant groups (Cheryan et al., 2017; Geesa et al., 2021; Reinholz et al., 2019; Sparks et al., 2021). The impact of such environments can potentially alienate even the most qualified individuals from non-dominant groups (Ito et al., 2025). Good and colleagues summarized that “when the sense of belonging is reduced, individuals may opt out of the domain—even when achievement remains high—to pursue studies and professional goals within a different discipline that better enables this sense of belonging to take root” (Good et al., 2012, p. 701). Simply, individuals may abandon their chemistry pursuits for other opportunities where they perceive they belong. Therefore, it is crucial that we explore and understand this phenomenon to create a more inclusive and equitable chemistry higher education.

Understanding the impact of these biases on students’ sense of belonging is crucial. Several aspects contribute to the bias in the culture of chemistry. For instance, students from historically excluded groups, which are a type of non-dominant group, often find

classroom spaces unwelcoming, competitive, and discriminatory toward students of color and women (Agrawal et al., 2016; Allen-Ramdial & Campbell, 2014; Castro, 2014; Davis & Wilson-Kennedy, 2023; Fries-Britt et al., 2013; Ito et al., 2025). They often face the burden of proving their intellectual capabilities to faculty and peers, irrespective of their preparation and performance. These experiences can diminish a student's sense of belonging, even if they are academically talented and, in principle, should belong in that space. Belonging must be grounded in the fundamental components of science identity and the environment, and members of the chemistry community must recognize the value of an individual's abilities, as well as when they may be underrecognizing an individual's abilities.

Mitigating bias in merit within chemistry involves implementing transformative approaches to objectively evaluate and address biases in policies, practices, instructional methods, funding, etc. These approaches should be grounded in the principles of objective meritocracy, ensuring that individuals are evaluated based on their abilities and accomplishments, rather than on factors unrelated to their qualifications. This emphasis on unbiased evaluation reassures the scientific community of the system's fairness, instilling confidence in the merit-based approach.

5. The Way Forward—Answering the Call

Decolonizing belonging in chemistry involves recognizing and addressing the deep-seated structural and systemic barriers that non-dominant groups navigate to belong in chemistry higher education. Wilson-Kennedy (2023) emphasizes that the focus needs to be on understanding and improving science learning and professional environments to be welcoming for all. Accordingly, decolonizing belonging calls for a comprehensive re-evaluation and transformation of higher education spaces to ensure that opportunities for fostering a sense of belonging are centered on an individual's competence and performance and that individuals are impartially recognized for the value of these abilities. This necessitated broadening our mindsets around how we value knowledge, what knowledge we value, and how we recognize excellence.

We believe the greatest opportunity for decolonizing belonging is transforming chemistry learning experiences. Individual faculty often have autonomy in how they approach their teaching and the way that they design learning experiences in their classrooms. Accordingly, we focus on steps individual faculty can take to recognize and counteract the influence of dominant group culture in chemistry spaces. Our recommendations emphasize teaching practices that promote success and inclusion for all students. While these examples are not exhaustive, they offer a useful starting point for purposeful action.

Reflective Practice and Self-Awareness: Individual faculty may be intentional about examining the lens through which they design instruction. Herein, they may reflect on personal preferences and biases, implicit and explicit assumptions about what excellence looks like to them, and how cultural assets and privilege influence their interactions with students (and colleagues) and their pedagogical practices. They may use journaling, self-assessments, dialogue with students and colleagues, exploration of literature, and other feedback opportunities to enhance self-awareness and accountability. See Supplemental Materials for a sample of reflection prompts that faculty may use to enhance self-awareness and advance reflective practice.

Broaden Content: Challenge and de-center dominant norms and narratives in the course policies and curriculum (Raycroft & Flynn, 2020). Learning environments are a critical element in shaping the experiences of individuals engaging in chemistry. As such, this strategy is a critical step to encourage the promotion of more perspectives and address biases to support belonging for all students. Some practical examples are:

Integrating scientific contributions, approaches, histories, epistemologies, and practices from non-dominant and marginalized communities into chemistry courses to provide a more comprehensive education (Gaotlhobogwe, 2023; Glazebrook, 2021; Howard et al., 2024). Resources can be leveraged to identify chemists from non-dominant groups (Brown, 2018; Rayner-Canham & Rayner-Canham, 2008; Society, 2021; Tamao, 2025).

Review all course policies, syllabi, assignments, and grading criteria thoroughly to identify and remove any potential biases or obstacles to learning that could unfairly disadvantage students from non-dominant groups. This includes but is not limited to considering any language, examples, or cultural references that may inadvertently marginalize certain groups of students. This may be approached by including content, readings, or other ways of knowing from non-Western and other non-dominant groups, incorporating case studies that explore the relevant context for the advancement of science, and other similar strategies (Herreid, 2007; National Center for Case Study Teaching in Science, 2025).

Engaging students in regionally relevant scientific issues can create a shared platform for exploring diverse perspectives and addressing issues that affect everyone (Behl et al., 2024; Johnson et al., 2020; Vance-Chalcraft & Jelks, 2023). This sense of community and shared responsibility fosters a feeling of connection and involvement among students, making the learning process more meaningful and engaging. For example, in Louisiana, U.S., a regional topic for discussion is how petrochemicals impact local air and water quality; this leverages chemistry concepts of hydrocarbon chemistry, toxicology, and environmental monitoring. In Kenya, topics on water purification could be explored using charcoal, Moringa seeds, or nanomaterials for clean water; chemistry concepts would focus on adsorption and filtration. In southern Asia, dye pollution from textile industries could be explored with a focus on chemical treatments and an analysis of effluents; chemistry concepts would focus on organic dyes, spectroscopy, and biodegradation. Together, these could provide regionally relevant topics for exploration in chemistry classrooms.

Validate Multiple Ways of Knowing: Utilize non-traditional and more contemporary learning approaches and practices to engage all groups of students. Understanding and valuing students' lived experiences in the learning process can be transformational in changing instructional practices to center belonging for all. When students see their own experiences reflected in the curriculum, they are likely to find the learning process more stimulating and the content more accessible, leading to a more thorough understanding and retention of knowledge and skills, and seeing themselves as valued members of the scientific community. Moreover, elevating student voice provides unique opportunities (Hurtado et al., 2009; Le et al., 2019; Yabang et al., 2025).

Universal Design for Learning (UDL), a learning theory that supports and accommodates the needs of all learners in the learning process by engaging them in a learning environment that presents information in a variety of ways (Rose, 2000). The UDL approach cultivates belonging by valuing different learning styles and needs and offering multiple ways of expressing knowledge and representing content (Heelan, 2015; Nelson, 2021), thereby illustrating a respect for epistemological difference. This approach provides guidance that may be leveraged to explicitly integrate non-dominant knowledge traditions, community-based practices, experiential learning, scientific storytelling, and other similar practices into instruction. Drawing on the UDL framework, learning activities and assessments can intentionally incorporate multiple means of representation, action, and expression, and engagement to ensure that all learners have meaningful opportunities to succeed (CAST, 2018; Reyes et al., 2022). In practice, this elevates valuing a range of outputs, such as tactile model construction, annotated molecular diagrams, interactive simulations, virtual laboratory reports, community-based projects, or collaborative problem-solving

sessions, as valid evidence of learning in chemistry (Baumann & Melle, 2019; Holländer & Melle, 2023; Horna-Saldana & Canaleta, 2024; Miano et al., 2023; Reyes et al., 2022).

UDL may be implemented in both small and large enrollment courses using a variety of flexible approaches. One strategy for exploring representational and conceptual knowledge could leverage a molecular geometry assessment in a small class to build and defend physical models, while students in a large enrollment course could demonstrate the same competency through digital drawing and/or drag-and-drop tasks in a learning management system (Padalkar & Hegarty, 2015; Ward et al., 2025). Both formats can provide meaningful ways to engage students in multiple models of action and expression. Moreover, both formats, when scored with consistent rubrics, can provide reliable and comparable measures of student performance (Logan & Mountain, 2018; McKnelly et al., 2021; Oliver-Hoyo, 2003). See Supplemental Materials for additional UDL examples.

Curriculum Redesign: Faculty can work collaboratively to systematically redesign curricula in ways that respectfully integrate diverse epistemologies and ways of knowing, elevating non-Western scholarship and non-dominant group perspectives. Leveraging attention to Indigenous knowledge systems, this process should be intentional in moving beyond token inclusion to authentic co-creation of content with communities and knowledge holders, ensuring cultural protocols, intellectual property rights, and community priorities are upheld (Ziebell et al., 2021; Zinyeka et al., 2016). Approaches such as “two-eyed seeing,” which bring together Indigenous and Western scientific perspectives to find common ground and produce stronger, more holistic outcomes, can guide this integration (Bartlett et al., 2012; Hatcher et al., 2009).

Practical strategies might include curriculum audits that identify epistemic and cultural biases; co-developed modules in which Indigenous and scientific inquiry processes are taught side-by-side; and place-based learning activities that embed time, place, and relationality as core scientific variables (Kristian et al., 2023; Latip et al., 2024). International examples demonstrate viable pathways: in Australia, chemistry laboratory projects have been developed in partnership with First Nations communities, with clear guidelines on when curriculum content can be developed independently by faculty and when collaboration is required to respect cultural authority (Ziebell et al., 2021); in Canada, New Zealand, and parts of Africa, local and Indigenous knowledge has been harmonized with formal science curricula through community-based, cross-cultural capability frameworks (Latip et al., 2024).

Faculty learning communities (FLCs): Faculty dialogue groups or learning communities offer a powerful structure for curricula change and personal reflection (Bailey et al., 2022; Beach et al., 2012; Cox, 2001). These communities provide a low-stakes environment for faculty to explore challenges, share practices, and build self-awareness over time. Moreover, engaging in reflection collectively, especially with peers from similar disciplines, encourages accountability and provides support when navigating complex issues such as bias, privilege, or inequities in learning environments, all topics salient to dominant group culture. Ongoing faculty development, embedded into the FLCs, could feature evidence-based practices with demonstrated efficacy with non-dominant groups. Herein, a series of lunch-and-learn workshops, or chew-and-chat sessions, focusing on innovations in assessment practices, anti-colonial pedagogies, and reimagined grading practices could provide a framework for building partnerships and collaborative action. Using UDL as a framework, chemistry faculty could explore a number of relevant instructional and assessment strategies (Drumm et al., 2024; D. K. Miller & Lang, 2016; Scanlon et al., 2018; Wojdak et al., 2024). Specifications grading could also be explored (Bunnell et al., 2023; Katzman et al., 2021; Streifer et al., 2024).

Notably, instructors in gateway chemistry courses often face strong content-coverage constraints. The recommendations mentioned heretofore do not have to be ‘extras’ but as

design choices that shape how existing core content is accessed, practiced, and assessed. For example, using a UDL framework, many strategies can be implemented through ‘swap, not add’ substitution by reimagining an existing active-learning task to include structured collaboration norms and multiple options for demonstrating the same learning outcome, with an explicit focus on belonging. Moreover, a tiered implementation pathway (low-lift changes → one-unit pilots → course-level redesign) and department-level supports such as shared artifacts and course materials can provide a manageable approach to engaging these changes. Herein, FLCs can be invaluable to this work.

6. Conclusions

By adopting a decolonization perspective informed by dominant group theory, faculty can pursue a number of approaches that foster belonging for all groups. Examples of specific approaches could include: (a) integrating non-Western scientific contributions into the curricula, (b) employing Universal Design for Learning (UDL) to accommodate multiple models of engagement, expression, and representation, and (c) employing evidence-based practices tailored to help the most vulnerable groups, thereby supporting the success of all (Amisi et al., 2024; de Sousa Santos et al., 2016; McClanahan, 2018). Additionally, adopting policies that promote the visibility of a wide array of role models provides resources that address the specific needs of marginalized groups, promoting a sense of recognition and validation within the academic community. By fostering an environment where students feel a strong sense of belonging, educators have an opportunity to enhance student motivation, retention, and overall well-being, ultimately contributing to a more diverse and productive scientific environment. This emphasis on belonging in chemistry higher education reflects a broader recognition of the importance of multifaceted perspectives, voices, and experiences in the chemistry enterprise.

Decolonizing belonging in chemistry requires our continuous commitment to addressing historical imbalances, existing power structures, and injustices that have long distorted who belongs in our learning spaces. While not all faculty are going to be inspired by this perspective, faculty who are motivated to foster belonging have leveraged this work as an evidentiary base and a practical set of strategies that can be used to begin and/or expand their work. The research-grounded rationales and adaptable entry points provided in this perspective may enable early adopters to champion the work locally—building social proof, shared language, and departmental capacity for broader uptake.

Transforming the existing fabric of higher education will require this type of intentional action, but the resulting outcomes will be worthwhile in our goal of broadening participation in our discipline. If we individually transform our respective areas of influence, we will have a collective effort that creates welcoming and engaging learning environments that recognize the efforts of all individuals without bias. Our collective efforts have the potential to produce an academic and professional ecosystem where individuals from all backgrounds feel equally valued and empowered to contribute to the advancement of science.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/educsci16020238/s1>, Table S1: Samples of UDL-Aligned Chemistry Activities and Assessments.

Author Contributions: Conceptualization, Z.S.W.-K. and R.D.D.; Methodology, Z.S.W.-K. and R.D.D.; Resources, Z.S.W.-K.; Data Curation, R.D.D., C.D.J. and Z.S.W.-K.; Writing—Original Draft Preparation, R.D.D. and C.D.J.; Writing—Review & Editing, Z.S.W.-K., R.D.D. and C.D.J.; Supervision, Z.S.W.-K.; Project Administration, Z.S.W.-K.; Funding Acquisition, Z.S.W.-K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by National Science Foundation grant numbers [2204741]; [1930474]; [2444876].

Data Availability Statement: Data is contained within the article and Supplementary Materials.

Acknowledgments: During the preparation of this manuscript/study, the author(s) used ChatGPT 5.0 for the purposes of collaborative creating samples of UDL-aligned chemistry activities and assessments as presented in Supplementary Materials. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

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

References

- Adame, F. (2021). Meaningful collaborations can end ‘helicopter research’. *Nature*, 10. Available online: <https://www.nature.com/articles/d41586-021-01795-1> (accessed on 14 December 2025).
- Adejumo, V. (2021). Beyond diversity, inclusion, and belonging. *Leadership*, 17(1), 62–73.
- Agrawal, R. K., Stevenson, M. L., & Gloster, C. (2016, June 26–29). *Understanding the reasons for low representation of ethnic minority students in STEM fields*. 2016 ASEE Annual Conference & Exposition, New Orleans, LA, USA.
- Allen, K.-A. (2025). School belonging: Evidence, experts, and everyday gaps. *Educational Psychology Review*, 37(3), 84.
- Allen, K.-A., Kern, M. L., Rozek, C. S., McInerney, D. M., & Slavich, G. M. (2021). Belonging: A review of conceptual issues, an integrative framework, and directions for future research. *Australian Journal of Psychology*, 73(1), 87–102.
- Allen, K.-A., Slaten, C., Hong, S., Lan, M., Craig, H., May, F., & Counted, V. (2024). Belonging in higher education: A twenty year systematic review. *Journal of University Teaching and Learning Practice*, 21(5), 1–55.
- Allen-Ramdial, S.-A. A., & Campbell, A. G. (2014). Reimagining the pipeline: Advancing STEM diversity, persistence, and success. *BioScience*, 64(7), 612–618.
- Amisi, A., Bates, E., & Wilbraham, S. (2024). How does the curriculum contribute to the experiences of belongingness in higher education? *Psychology Teaching Review*, 30(1), 96–106.
- Apple, M., & Apple, M. W. (2004). *Ideology and curriculum*. Routledge.
- Asase, A., Mzumara-Gawa, T. I., Owino, J. O., Peterson, A. T., & Saupe, E. (2022). Replacing “parachute science” with “global science” in ecology and conservation biology. *Conservation Science and Practice*, 4(5), e517.
- Bailey, E., Le Vin, A., Miller, L., Price, K., Sneddon, S., Stapleton, G., & Wolfe, L. (2022). Bridging the transition to a new expertise in the scholarship of teaching and learning through a faculty learning community. *International Journal for Academic Development*, 27(3), 265–278.
- Bartlett, C., Marshall, M., & Marshall, A. (2012). Two-Eyed Seeing and other lessons learned within a co-learning journey of bringing together indigenous and mainstream knowledges and ways of knowing. *Journal of Environmental Studies and Sciences*, 2(4), 331–340. <https://doi.org/10.1007/s13412-012-0086-8>.
- Baumann, T., & Melle, I. (2019). Evaluation of a digital UDL-based learning environment in inclusive chemistry education. *Chemistry Teacher International*, 1(2), 20180026. <https://doi.org/10.1515/cti-2018-0026>.
- Baumeister, R. F., & Leary, M. R. (2017). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. In *Interpersonal development* (pp. 57–89). Routledge.
- Bayar, A., & Karaduman, H. A. (2021). The effects of school culture on students academic achievements. *Shanlax International Journal of Education*, 9(3), 99–109.
- Beach, A. L., Henderson, C., & Finkelstein, N. (2012). Facilitating change in undergraduate STEM education. *Change: The Magazine of Higher Learning*, 44(6), 52–59.
- Behl, M., Harrison, J., Walton, M., Riseng, C., Peroff, D. M., Meltzer, H., Maung-Douglass, E., Lovelace, S., Lake, S. J., & Kennedy, M. (2024). Sea Grant’s community engaged internship: Expanding participation and cultivating belonging in coastal and ocean sciences. *Journal of Environmental Studies and Sciences*, 14, 581–593.
- Belanger, A. L., Joshi, M. P., Fuesting, M. A., Weisgram, E. S., Claypool, H. M., & Diekman, A. B. (2020). Putting belonging in context: Communal affordances signal belonging in STEM. *Personality and Social Psychology Bulletin*, 46(8), 1186–1204.
- Bhopal, K. (2020). Confronting White privilege: The importance of intersectionality in the sociology of education. *British Journal of Sociology of Education*, 41(6), 807–816.

- Blair-Loy, M., & Cech, E. A. (2022). *Misconceiving merit: Paradoxes of excellence and devotion in academic science and engineering*. University of Chicago Press.
- Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, 17, 369–386. <https://doi.org/10.1080/09540250500145072>.
- Bourdieu, P. (1986). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education*. Greenwood Press.
- Bourdieu, P. (1991). *Language and symbolic power*. Harvard University Press.
- Brockman, A. J. (2021). “La Crème de la Crème”: How racial, gendered, and intersectional social comparisons reveal inequities that affect sense of belonging in STEM. *Sociological Inquiry*, 91(4), 751–777.
- Brown, J. E. (2018). *African American women chemists in the modern era*. Oxford University Press.
- Bunnell, B., LeBourgeois, L., Doble, J., Gute, B., & Wainman, J. W. (2023). Specifications-based grading facilitates student–instructor interactions in a flipped-format general chemistry II course. *Journal of Chemical Education*, 100(11), 4318–4326.
- Burke, A., Okrent, A., Hale, K., & Gough, N. (2022). *The state of US science & engineering 2022. National science board science & engineering indicators*. NSB-2022-1. National Science Foundation.
- Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44, 1187–1218. <https://doi.org/10.1002/tea.20237>.
- Carter, P. L., & Welner, K. G. (2013). *Closing the opportunity gap: What America must do to give every child an even chance*. Oxford University Press.
- Castro, E. L. (2014). “Underprepared” and “at-risk”: Disrupting deficit discourses in undergraduate STEM recruitment and retention programming. *Journal of Student Affairs Research and Practice*, 51(4), 407–419.
- Center for Applied Special Technology. (2018). *Universal design for learning*. CAST. Available online: <https://www.cast.org/what-we-do/universal-design-for-learning/> (accessed on 14 December 2025).
- Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, 143, 1–35. <https://doi.org/10.1037/bul0000052>.
- Cicek, J. S., Masta, S., Goldfinch, T., & Kloot, B. (2023). Decolonization in engineering education. In *International handbook of engineering education research* (pp. 51–86). Routledge.
- Clements, T. P., Friedman, K. L., Johnson, H. J., Meier, C. J., Watkins, J., Brockman, A. J., & Brame, C. J. (2022). “It made me feel like a bigger part of the STEM community”: Incorporation of learning assistants enhances students’ sense of belonging in a large introductory biology course. *CBE—Life Sciences Education*, 21(2), ar26.
- Covarrubias, R. (2024). What does it mean to belong? An interdisciplinary integration of theory and research on belonging. *Social and Personality Psychology Compass*, 18(1), e12858.
- Cox, M. D. (2001). Faculty learning communities: Change agents for transforming institutions into learning organizations. *To Improve the Academy*, 19, 69–93.
- Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights from the Behavioral and Brain Sciences*, 1, 21–29. <https://doi.org/10.1177/2372732214549471>.
- Davis, R. D., & Wilson-Kennedy, Z. (2023). Leveraging cultural wealth, identities and motivation: How diverse intersectional groups of low-income undergraduate stem students persist in collegiate STEM environments. *Education Sciences*, 13(9), 888.
- Delpit, L. (2006). *Other people’s children: Cultural conflict in the classroom*. The New Press.
- de Sousa Santos, B., Nimako, K., Maldonado-Torres, N., Burman, A., Aman, R., Sithole, T., Pérez-Bustillo, C., Pitts, A. J., Reed-Sandoval, A., & Cepeda, L. R. D. (2016). *Decolonizing the westernized university: Interventions in philosophy of education from within and without*. Lexington Books.
- Dortch, D., & Patel, C. (2017). Black undergraduate women and their sense of belonging in STEM at predominantly White institutions. *NASPA Journal About Women in Higher Education*, 10, 202–215. <https://doi.org/10.1080/19407882.2017.1331854>.
- Drumm, B. T., Bree, R., Griffin, C. S., & O’Leary, N. (2024). Diversifying laboratory assessment modes broadens engagement with practical competencies in life science students. *Advances in Physiology Education*, 48(3), 527–546.
- Duncan, J. R., & Zeng, Y. (2005). *Women: Support factors and persistence in engineering*. National Center for Engineering and Technology Education.
- Fluit, S., Cortés-García, L., & von Soest, T. (2024). Social marginalization: A scoping review of 50 years of research. *Humanities and Social Sciences Communications*, 11(1), 1665.

- Fong, C. J., Adelugba, S. F., Garza, M., Pinto, G. L., Gonzales, C., Zarei, P., & Rozek, C. S. (2024). A scoping review of the associations between sense of belonging and academic outcomes in postsecondary education. *Educational Psychology Review*, 36(4), 138.
- Freeman, M. A., & Ortiz, A. M. (2019). Promoting engagement and belonging. In *Student affairs in urban-serving institutions* (pp. 84–104). Routledge.
- Fries-Britt, S., Johnson, J., & Burt, B. (2013). Black students in physics. In *Living at the intersections* (pp. 21–39). IAP Information Age Publishing.
- Gaotlhobogwe, M. (2023). Making a case for Indigenous technological knowledge systems education in science, technology, engineering and mathematics. In *Indigenous technology knowledge systems: Decolonizing the technology education curriculum* (pp. 19–32). Springer.
- Geesa, R. L., Rose, M. A., Stith, K. M., Lowery, K., & Caniglia, J. (2021). Equity, diversity, and inclusion within integrative STEM education. *Leadership in Integrative STEM Education: Collaborative Strategies for Facilitating an Experiential and Student-Centered Culture*, 51, 51–66.
- Gichuru, J. (2024). Enhancing STEM education through equity, diversity, inclusion and decolonization. In *Global perspectives on STEM education: Theory and practice* (pp. 29–50). Springer.
- Gilani, D., McArthur, D., & Thomas, L. (2024). The promise and limitations of student belonging as a predictor of retention. *Trends in Higher Education*, 3(4), 993–1016.
- Gjovik, A. M. (2025). Decolonizing the natural sciences: The colonial foundations of western scientific authority. *The Journal of Decolonized Ecology & Evolution*, 1(1), 2.
- Glazebrook, T. (2021). What is worth knowing? Science, knowledge, and gendered and indigenous knowledge-systems. *Axiomathes*, 31(6), 727–741.
- Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology*, 102(4), 700.
- Gopalan, M., & Brady, S. T. (2020). College students' sense of belonging: A national perspective. *Educational Researcher*, 49(2), 134–137.
- Graulich, N., Kahveci, A., Lawrie, G. A., Lewis, S. E., & Nyachwaya, J. (2023). Laying the foundations to build on: Exploring diversity in our chemistry education research & practice community. *Chemistry Education Research and Practice*, 24(1), 8–11. <https://doi.org/10.1039/D2RP90012B>.
- Gravett, K., & Ajjawi, R. (2022). Belonging as situated practice. *Studies in Higher Education*, 47(7), 1386–1396.
- Hansen, M. J., Palakal, M. J., & White, L. J. (2023). The importance of STEM sense of belonging and academic hope in enhancing persistence for low-income, underrepresented STEM students. *Journal for STEM Education Research*, 7, 155–180.
- Harris, C. M. (2019). Quitting science: Factors that influence exit from the STEM workforce. *Journal of Women and Minorities in Science and Engineering*, 25(2), 93–118.
- Hatcher, A., Bartlett, C., Marshall, A., & Marshall, M. (2009). Two-eyed seeing in the classroom environment: Concepts, approaches, and challenges. *Canadian Journal of Science, Mathematics and Technology Education*, 9(3), 141–153. <https://doi.org/10.1080/14926150903118342>.
- Hays, P. A. (2008). *Addressing cultural complexities in practice: Assessment, diagnosis, and therapy* (2nd ed.) American Psychological Association.
- Heelan, A. (2015, November 12–13). *Universal design for learning (UDL): Implications for education*. Universal Design in Education, Dublin, Ireland.
- Herreid, C. F. (2007). *Start with a story: The case study method of teaching college science*. NSTA press.
- Holländer, M., & Melle, I. (2023). ChemDive—A classroom planning tool for infusing Universal Design for Learning. *Chemistry Teacher International*, 5(2), 165–176. <https://doi.org/10.1515/cti-2022-0039>.
- Hooks, B. (2014). *Teaching to transgress*. Routledge.
- Horna-Saldana, C., & Canaleta, X. (2024). Application of universal design for learning and digital fabrication in the creation of a tool for inclusive teaching of the ordering of chemical elements. *Journal of Chemical Education*, 101(12), 5261–5271.
- Howard, M., Alexiades, A., Schuster, C., & Raya, R. (2024). Indigenous student perceptions on cultural relevance, career development, and relationships in a culturally relevant undergraduate STEM program. *International Journal of Science and Mathematics Education*, 22(1), 1–23.
- Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education*, 50(2), 189–214.

- Hurtado, S., & Carter, D. F. (1997). Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging. *Sociology of Education*, 70, 324–345.
- Ito, T. A., Folberg, A. M., Moser, C. E., & Pietri, E. S. (2025). Keeping America Great: The Importance of Broadening Participation in STEM. *Social and Personality Psychology Compass*, 19(11), e70092.
- Jackson, L. O. (2016). *Sense of belonging of Black students in STEM majors: A mixed methods study*. Virginia Commonwealth University.
- Jin, Q. (2021). Supporting indigenous students in science and STEM education: A systematic review. *Education Sciences*, 11(9), 555.
- Johnson, M. D., Sprowles, A. E., Goldenberg, K. R., Margell, S. T., & Castellino, L. (2020). Effect of a place-based learning community on belonging, persistence, and equity gaps for first-year STEM students. *Innovative Higher Education*, 45, 509–531.
- Katzman, S. D., Hurst-Kennedy, J., Barrera, A., Talley, J., Javazon, E., Diaz, M., & Anzovino, M. E. (2021). The effect of specifications grading on students' learning and attitudes in an undergraduate-level cell biology course. *Journal of Microbiology & Biology Education*, 22(3), e00200-00221.
- Khalid, R., & Ting, I. J. (2025). From margins to mainstream: Decolonizing science and promoting diversity for the future of STEM. *Frontiers in Education*, 10, 1515125. <https://doi.org/10.3389/educ.2025.1515125>.
- Kim, A. Y., & Sinatra, G. M. (2018). Science identity development: An interactionist approach. *International Journal of STEM Education*, 5, 51. <https://doi.org/10.1186/s40594-018-0149-9>.
- Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research*, 88, 589–625. <https://doi.org/10.3102/0034654318779957>.
- Kingston, P. W. (2001). The unfulfilled promise of cultural capital theory. *Sociology of Education*, 74, 88–99.
- Kirby, L. A., & Thomas, C. L. (2022). High-impact teaching practices foster a greater sense of belonging in the college classroom. *Journal of Further and Higher Education*, 46(3), 368–381.
- Kozłowski, D., Larivière, V., Sugimoto, C. R., & Monroe-White, T. (2022). Intersectional inequalities in science. *Proceedings of the National Academy of Sciences*, 119(2), e2113067119.
- Kristian, K. E., Andruk, C., Gaines, B., Varner, M., Smith, M., & Stabile, J. (2023). Place-based learning and real-world context in general chemistry laboratory via urban ecology and green chemistry. In *Engaging chemistry students with real-world context: Volume 2* (pp. 57–72). ACS Publications.
- Kumashiro, K. K. (2000). Toward a theory of anti-oppressive education. *Review of Educational Research*, 70(1), 25–53. <https://doi.org/10.3102/00346543070001025>.
- Lambert, W. M., Camacho-Rivera, M., Boutin-Foster, C., Salifu, M., & Riley, W. J. (2024). Ending “domestic helicopter research”. *Cell*, 187(8), 1823–1827.
- Lamont, M., & Lareau, A. (1988). Cultural capital: Allusions, gaps and glissandos in recent theoretical developments. *Sociological Theory*, 6, 153–168.
- Latip, A., Hernani, & Kadarohman, A. (2024). Local and indigenous knowledge (LIK) in science learning: A systematic literature review. *Journal of Turkish Science Education*, 21(4), 651–667. <https://doi.org/10.36681/tused.2024.035>.
- Le, P. T., Doughty, L., Thompson, A. N., & Hartley, L. M. (2019). Investigating undergraduate biology students' science identity production. *CBE—Life Sciences Education*, 18(4), ar50. <https://doi.org/10.1187/cbe.18-10-0204>.
- Li, Y., & Singh, C. (2023). Sense of belonging is an important predictor of introductory physics students' academic performance. *Physical Review Physics Education Research*, 19(2), 020137.
- Logan, K., & Mountain, L. (2018). Writing instruction in chemistry classes: Developing prompts and rubrics. *Journal of Chemical Education*, 95(10), 1692–1700.
- Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370–396. <https://doi.org/10.1037/h0054346>.
- McCabe, J. (2009). Racial and gender microaggressions on a predominantly-White campus: Experiences of Black, Latina/o and White undergraduates. *Race, Gender & Class*, 16, 133–151.
- McClanahan, J. L. (2018). *Culturally relevant pedagogy and its impact on student belonging*. University of North Carolina at Greensboro.
- McKnelly, K. J., Morris, M. A., & Mang, S. A. (2021). Redesigning a “writing for chemists” course using specifications grading. *Journal of Chemical Education*, 98(4), 1201–1207.
- Meehan, C., & Howells, K. (2019). In search of the feeling of ‘belonging’ in higher education: Undergraduate students transition into higher education. *Journal of Further and Higher Education*, 43(10), 1376–1390.
- Ménard, A. D., Pitre, A., Milidrag, L., & Chittle, L. (2024). Students' descriptions of belonging experiences in post-secondary settings. *Learning Environments Research*, 27, 649–667.
- Miano, J., Perral, C. A., Pingal, P. J., & Pitogo, M. A. (2023). *UDL and students' academic achievement in chemistry* (Preprint). ResearchGate. Available online: <https://doi.org/10.3390/educsci16020238>

- https://www.researchgate.net/publication/375090631_UDL_and_Students'_Academic_Achievement_in_Chemistry (accessed on 14 December 2025).
- Miller, A. L., Williams, L. M., & Silberstein, S. M. (2019). Found my place: The importance of faculty relationships for seniors' sense of belonging. *Higher Education Research & Development*, 38(3), 594–608.
- Miller, D. K., & Lang, P. L. (2016). Using the universal design for learning approach in science laboratories to minimize student stress. *Journal of Chemical Education*, 93(11), 1823–1828.
- Morton, T. R., & Nkrumah, T. (2021). A day of reckoning for the white academy: Reframing success for African American women in STEM. *Cultural Studies of Science Education*, 16(2), 485–494.
- National Center for Case Study Teaching in Science. (2025). *Case study listserv*. National Science Teaching Association.
- 2023) National Center for Science and Engineering Statistics (NCSES). (2023). *Diversity and STEM: Women, minorities, and persons with disabilities* 2023. Special Report NSF 23-315. National Center for Science and Engineering Statistics. Available online: <https://www.nsf.gov/reports/statistics/diversity-stem-women-minorities-persons-disabilities-2023> (accessed on 14 December 2025).
- Nelson, L. L. (2021). Using the Universal Design for Learning framework to understand the power of belonging. In *Belonging and resilience in individuals with developmental disabilities: Community and family engagement* (pp. 49–66). Springer.
- Odeny, B., & Bosurgi, R. (2022). Time to end parachute science. *PLoS Medicine*, 19, e1004099.
- Oliver-Hoyo, M. T. (2003). Designing a written assignment to promote the use of critical thinking skills in an introductory chemistry course. *Journal of Chemical Education*, 80(8), 899.
- O'Neill, T., Finau-Faumuina, B. M., & Ford, T. U. L. (2023). Toward decolonizing STEM: Centering place and sense of place for community-based problem-solving. *Journal of Research in Science Teaching*, 60(8), 1755–1785.
- Ovink, S. M., Byrd, W. C., Nanney, M., & Wilson, A. (2024). "Figuring out your place at a school like this:" Intersectionality and sense of belonging among STEM and non-STEM college students. *PLoS ONE*, 19(1), e0296389.
- Padalkar, S., & Hegarty, M. (2015). Models as feedback: Developing representational competence in chemistry. *Journal of Educational Psychology*, 107(2), 451.
- Patel, L. (2015). *Decolonizing educational research: From ownership to answerability*. Routledge.
- Philip, T. M., & Azevedo, F. S. (2017). Everyday science learning and equity: Mapping the contested terrain. *Science Education*, 101(4), 526–532.
- Pokhrel, A. K. (2011). Eurocentrism. In D. K. Chatterjee (Ed.), *Encyclopedia of global justice* (pp. 321–325). Springer.
- Quijano, A. (2000). Coloniality of power and Eurocentrism in Latin America. *International Sociology*, 15(2), 215–232.
- Ravishankar, S., Spencer-Drakes, T. C., Fernandes, I. H., Hayes, M. I., Coopwood, S., Spencers, I., & Neal, S. E. (2024). Empowering STEM students: A university-wide mentorship program fostering retention and belonging. *bioRxiv*. <https://doi.org/10.1101/2024.04.02.587784>.
- Raycroft, M. A. R., & Flynn, A. B. (2020). What works? What's missing? An evaluation model for science curricula that analyses learning outcomes through five lenses. *Chemistry Education Research and Practice*, 21(4), 1110–1131. <https://doi.org/10.1039/C9RP00157C>.
- Rayner-Canham, M. F., & Rayner-Canham, G. (2008). *Chemistry was their life: Pioneering British women chemists, 1880–1949*. Imperial College Press.
- Razzante, R. J., & Orbe, M. P. (2018). Two sides of the same coin: Conceptualizing dominant group theory in the context of co-cultural theory. *Communication Theory*, 28(3), 354–375.
- Reinholz, D. L., Matz, R. L., Cole, R., & Apkarian, N. (2019). STEM is not a monolith: A preliminary analysis of variations in STEM disciplinary cultures and implications for change. *CBE Life Sciences Education*, 18, mr4.
- Reyes, C. T., Lawrie, G. A., Thompson, C. D., & Kyne, S. H. (2022). "Every little thing that could possibly be provided helps": Analysis of online first-year chemistry resources using the universal design for learning framework. *Chemistry Education Research and Practice*, 23(2), 385–407. <https://doi.org/10.1039/D1RP00171J>.
- Rodriguez, S. L., & Blaney, J. M. (2021). "We're the unicorns in STEM": Understanding how academic and social experiences influence sense of belonging for Latina undergraduate students. *Journal of Diversity in Higher Education*, 14(3), 441.
- Roithmayr, D. (1998). Deconstructing the distinction between bias and merit. *La Raza LJ*, 10, 363.
- Roldan-Hernandez, L., Boehm, A. B., & Mihelcic, J. R. (2020). Parachute environmental science and engineering. *Environmental Science & Technology*, 54, 14773–14774.
- Rose, D. (2000). Universal design for learning. *Journal of Special Education Technology*, 15(4), 47–51.

- Sandrone, S. (2022). Science identity and its “identity crisis”: On science identity and strategies to foster self-efficacy and sense of belonging in STEM. *Frontiers in Education*, 7, 871869.
- Scanlon, E., Legron-Rodriguez, T., Schreffler, J., Ibadlit, E., Vasquez, E., & Chini, J. J. (2018). Postsecondary chemistry curricula and universal design for learning: Planning for variations in learners’ abilities, needs, and interests. *Chemistry Education Research and Practice*, 19(4), 1216–1239.
- Shahjahan, R. A., Estera, A. L., Surla, K. L., & Edwards, K. T. (2022). “Decolonizing” curriculum and pedagogy: A comparative review across disciplines and global higher education contexts. *Review of Educational Research*, 92(1), 73–113.
- Society, A. C. (2021). *African American chemists: Academia, industry, and social entrepreneurship*. ACS Publications.
- Song, Y., Kim, A. Y., Martin-Hansen, L. M., & Bernal, E. V. (2020). Switching lanes or exiting? STEM experiences, perceptions, and identity construction among college STEM switchers. In *Critical questions in STEM education* (pp. 227–249). Springer.
- Sparks, D. M., Przymus, S. D., Silveus, A., De La Fuente, Y., & Cartmill, C. (2021). Navigating the intersectionality of race/ethnicity, culture, and gender identity as an aspiring Latina STEM student. *Journal of Latinos and Education*, 22, 1355–1371.
- Stefanoudis, P. V., Licuanan, W. Y., Morrison, T. H., Talma, S., Veitayaki, J., & Woodall, L. C. (2021). Turning the tide of parachute science. *Current Biology*, 31(4), R184–R185.
- Stein, S., & Andreotti, V. D. O. (2016). Decolonization and higher education. In *Encyclopedia of educational philosophy and theory*. Springer Science+ Business Media. https://doi.org/10.1007/978-981-287-532-7_479-1.
- Strayhorn, T. L. (2018). *College students’ sense of belonging: A key to educational success for all students*. Routledge.
- Streifer, A., Palmer, M., & Taggart, J. (2024). From expectations to experiences: Students’ perceptions of specifications grading in higher education. *International Journal for the Scholarship of Teaching and Learning*, 18(2), 5.
- Sullivan, A. (2002). Bourdieu and education: How useful is Bourdieu’s theory for researchers? *Netherlands Journal of Social Sciences*, 38, 144–166.
- Tamao, S. (2025). Doing science in our own way: Six oral histories of scientists with disabilities. *The Oral History Review*, 52(1), 137–158.
- Tatum, B. D. (2017). *Why are all the Black kids sitting together in the cafeteria?: And other conversations about race*. Basic Books.
- Taylor, M., & Turk, J. (2019). *Race and ethnicity in higher education: A look at low-income undergraduates*. Available online: <https://www.equityinhighered.org/resources/ideas-and-insights/race-and-ethnicity-in-higher-education-a-look-at-low-income-undergraduates> (accessed on 14 December 2025).
- Tellhed, U., Bäckström, M., & Björklund, F. (2017). Will I fit in and do well? The importance of social belongingness and self-efficacy for explaining gender differences in interest in STEM and HEED majors. *Sex Roles*, 77, 86–96.
- Thiry, H., Weston, T. J., Harper, R. P., Holland, D. G., Koch, A. K., & Drake, B. M. (2019). *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Springer Nature.
- Tilbrook, N., & Shifrer, D. (2022). Field-specific cultural capital and persistence in college majors. *Social Science Research*, 103, 102654.
- Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition*. ERIC.
- Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition*. University of Chicago Press.
- Tuhiwai Smith, L. (2012). *Decolonizing methodologies: Research and indigenous peoples*. Zed Books Ltd.
- Vance-Chalcraft, H. D., & Jelks, N. T. O. (2023). Community-engaged learning to broaden the impact of applied ecology: A case study. *Ecological Applications*, 33(5), e2768.
- Walker, K., George-Jackson, C., Rincon, B., Williams, M., Baber, L., & Trent, W. (2010). *STEM intervention programs: The shift from opportunity to merit*. Association of the Study of Higher Education Conference Paper. Available online: <https://www.semanticscholar.org/paper/STEM-Intervention-Programs%3A-The-Shift-from-to-Merit-Walker-George-Jackson/7f2899011469e1613f4191cb5a6cad995986019> (accessed on 14 December 2025).
- Ward, L., Rotich, F., Raker, J. R., Komperda, R., Nedungadi, S., & Popova, M. (2025). Design, development, and evaluation of the organic chemistry representational competence assessment (ORCA). *Chemistry Education Research and Practice*, 26(1), 244–258.
- Williams, J., Phillips, K., & Hall, E. (2014). *Double jeopardy? Gender bias against women of color in science*. Hastings College of the Law, Center for WorkLife Law.
- Wilson-Kennedy, Z. S. (2023). Omwana Ni Wa Bhone ... It takes a village. Available online: <https://aaas-iuse.org/omwana-ni-wa-bhone/> (accessed on 14 December 2025).
- Wilson-Kennedy, Z. S., Payton-Stewart, F., & Winfield, L. L. (2020). Toward intentional diversity, equity, and respect in chemistry research and practice. *Journal of Chemical Education*, 97(8), 2041–2044. <https://doi.org/10.1021/acs.jchemed.0c00963>.

- Wilson-Kennedy, Z. S., Winfield, L. L., Nielson, J., Arriaga, E. A., Kimble-Hill, A. C., & Payton-Stewart, F. (2022). Introducing the journal of chemical education's special issue on diversity, equity, inclusion, and respect in chemistry education research and practice. *Journal of Chemical Education*, 99(1), 1–4. <https://doi.org/10.1021/acs.jchemed.1c01219>.
- Wojdak, K., Smith, M. K., Orndorf, H., & Ramirez, M. L. (2024). Evaluating universal design for learning and active learning strategies in biology open educational resources (OERs). *Teaching & Learning Inquiry*, 12, 1–12.
- Yabang, W., Manning, E. E., Mate, K. E., Endacott, S. K., & Cameron, G. J. M. (2025). Indigenous student engagement in science: A case study addressing the lack of diversity and equity in biomedical science and pharmacy research for Aboriginal and Torres Strait islander people. *Immunology & Cell Biology*, 103(3), 256–264. <https://doi.org/10.1111/imcb.70007>.
- Yosso, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education*, 8(1), 69–91.
- Ziebell, A., Overton, T. L., & Yunkaporta, T. (2021). Australian indigenous knowledge in the undergraduate teaching laboratory. *International Journal of Innovation in Science and Mathematics Education*, 29, 32–46.
- Zinyeka, G., Onwu, G. O. M., & Braun, M. (2016). A truth-based epistemological framework for supporting teachers in integrating indigenous knowledge into science teaching. *African Journal of Research in Mathematics, Science and Technology Education*, 20(3), 256–266. <https://doi.org/10.1080/18117295.2016.1239963>.

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