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Barriers and Innovations: Promoting Inclusion in South Dakota's Engineering Education

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Abstract

This paper is a systematic critical review focused on secondary sources that reflect how inclusion in engineering education has advanced in South Dakota for the last ten years, a region distinguished by its varied population that is not reflected in the student body statistics. As the research design focuses on synthesizing existing evidence to evaluate inclusive engineering education policies and practices in South Dakota, it is derived from academic publications, institutional reports, and policy documents. This study seeks to identify gaps and educational practices hindering inclusivity in engineering education. We also want to make visible the criteria that constrain the design of educational programs and curricula in engineering education. To address these goals, we reviewed academic and policy documents spanning the past decade and analyzed how inclusive education within engineering education in South Dakota has advanced.

Our findings suggest that while some efforts and research have been made to foster inclusivity in engineering programs, significant opportunities for further study and intervention still exist. Additionally, more research is needed to understand how these initiatives affect the broader student population and their ability to cultivate mutual respect and understanding across different contexts. A new challenge in this landscape arises from state-imposed restrictions, echoing the national regulations, that limit the development of targeted educational programs specifically aimed at particular groups. These restrictions have made it increasingly difficult for institutions to create specialized support systems that directly address the needs of specific populations. Consequently, there is a pressing need for innovative solutions that comply with these legal constraints while fostering a sense of belonging and inclusion for all students.

Programs encompassing underrepresented and non-underrepresented populations may serve as a bridge, supporting collaboration and understanding across different cultural and social experiences. When properly designed, such initiatives can help ensure that all students—regardless of background—develop the competencies and skills necessary to succeed in an interconnected world. However, these broader initiatives must be carefully evaluated to ensure they do not inadvertently reduce the focus on the unique challenges faced by specific student groups. Instead, they should create an environment where everyone can contribute and thrive, enriching all students' overall academic and social experience.

Introduction

Inclusion in engineering education refers to the deliberate efforts to create environments that embrace diverse identities and provide equitable opportunities for students from all backgrounds to succeed in engineering fields (Lord et al., 2019; National Science Foundation, 2019). Inclusion also involves addressing systemic barriers and fostering cultural, social, and academic environments that value the contributions of underrepresented groups. Diverse identities relevant to inclusion in engineering education encompass race, ethnicity, gender, socioeconomic status, disability, and sexual orientation. Historically marginalized groups, including women, racial and ethnic minorities, and individuals with disabilities, face unique challenges in accessing and thriving in engineering education (Foor, Walden, & Trytten, 2007).

South Dakota presents a unique case for studying inclusion in engineering education due to its demographics, including a significant Native American population (9%) and rural communities traditionally underrepresented in STEM (National Science Foundation, 2019). However, there is limited publicly available data on underrepresented populations in engineering across the state. The South Dakota School of Mines and Technology (SD Mines) provides a partial picture, where its undergraduate engineering population for 2023 was 85% white, with Hispanic (5%), multi-ethnic (3%), Asian (2%), and Black (1%) students making up smaller percentages (South Dakota Mines, 2023). Women represent only 24% of undergraduates and 25% of engineering bachelor's degree recipients (Mapping Your Future, 2025). Nationally, underrepresented minorities earn higher percentages of engineering degrees—African Americans at 4.1% and Hispanics at 11.1% (ASEE, 2020). While South Dakota’s public universities

reported a 2% enrollment increase in 2023 (South Dakota Board of Regents, 2023), the overall participation of women and minorities in engineering remains lower than in more demographically diverse states. The lack of comprehensive statewide data underscores the need for further research and stronger diversity initiatives in South Dakota's engineering education system (National Science Foundation, 2019; Seymour & Hewitt, 1997; NCES, 2021; National Academies of Sciences, Engineering, and Medicine, 2017).

Inclusive engineering education enables students to develop intercultural competencies for addressing global challenges. By working alongside peers with diverse perspectives, students gain exposure to different cultural and social paradigms, broadening their understanding of global engineering practices (Joubert et al., 2020). Diversity in engineering teams also leads to innovative and robust solutions for complex problems. Research demonstrates that heterogeneous teams outperform homogeneous ones in creative problem-solving, which is crucial for tackling challenges like climate change and infrastructure development (Hong & Page, 2004).

Engineering has traditionally been associated with technical and analytical approaches, yet inclusion encourages blending these discourses with social and human-centric perspectives. This engineering approach fosters holistic practices that address societal needs. Furthermore, incorporating voices historically excluded from engineering ensures that technologies and systems are equitable and representative. Including underrepresented groups allows engineering solutions to cater to a broader audience, reflecting diverse societal needs (Lord et al., 2019).

The absence of inclusion in engineering education often leads to significant challenges for individuals and society. Exclusion from engineering education can result in feelings of isolation and alienation among underrepresented students. These factors can significantly impact mental health and academic persistence, perpetuating underrepresentation (Basile & Beauregard, 2016). Moreover, the underutilization of diverse talent in engineering contributes to economic stagnation in marginalized communities. Encouraging inclusivity can enhance the socioeconomic mobility of these populations, benefiting both individuals and the broader economy (National Academies of Sciences, Engineering, and Medicine, 2017).

Beyond economic impacts, inclusive engineering education fosters essential soft skills such as communication, empathy, and teamwork. Research shows that these attributes are critical for professional and personal growth, as they enable individuals to effectively collaborate and adapt in diverse work environments (Gonzalez & Wagenaar, 2003; Campbell et al., 2018). Developing such competencies also prepares students to engage with interdisciplinary teams, a vital skill in addressing complex engineering challenges (Prince & Felder, 2006).

Literature Review

Despite the increasing focus on diversity and inclusion in STEM education, there is a notable absence of comprehensive literature reviews examining inclusivity in South Dakota engineering education. This gap highlights the need for a targeted review to understand how inclusion has been studied and implemented in this unique demographic and geographic setting.

The aim of this study is multifaceted: to explore how inclusion has been addressed in engineering education research in South Dakota, to identify existing gaps and barriers in practices, and to illuminate the criteria that constrain the design of inclusive educational programs and curricula. These objectives are grounded in recognizing that inclusive practices are essential for fostering equitable opportunities and diversifying engineering disciplines (Lord et al., 2019; National Academies of Sciences, Engineering, and Medicine, 2017).

We critically reviewed secondary sources such as academic and policy documents from the past decade to achieve these goals. This analysis spans peer-reviewed journal articles, government reports, and institutional policies, providing a comprehensive overview of progress in inclusive engineering education in South Dakota. The review focuses on key aspects such as access to higher education for underrepresented populations, integrating inclusive teaching practices, and developing programs that promote diversity in STEM fields (National Science Foundation, 2019; Seymour & Hewitt, 1997).

Given South Dakota's distinctive demographic composition, including a significant Native American population and predominantly rural communities, understanding the intersection of local sociocultural dynamics and engineering education is critical. Research has shown that rural and Indigenous students face unique challenges in accessing and thriving in STEM fields, such as systemic inequities, limited resources, and cultural dissonance in predominantly Eurocentric educational frameworks (Foor, Walden, & Trytten, 2007; Smith et al., 2018).

This study also seeks to identify practices that hinder inclusivity, including the persistence of implicit biases, the lack of representation in faculty and leadership positions, and curricula that fail to reflect diverse perspectives (McGee, 2020). Additionally, the review examines how structural and financial constraints influence the design and implementation of inclusive programs, echoing findings from broader studies on diversity in higher education (Basile & Beauregard, 2016; National Academies of Sciences, Engineering, and Medicine, 2017).

Methodology

This systematic critical review (Grand & Booth, 2009) aims to answer a primary research question that guides the exploration of inclusion in engineering education in South Dakota: How has inclusion in engineering education advanced in South Dakota over the last ten years? Auxiliary questions support this study, including: How has inclusion in engineering education been researched and implemented? What gaps and educational practices could hinder inclusivity in engineering education? What criteria constrain the design of inclusive educational programs and curricula in engineering education within South Dakota? These questions are the foundation for this critical review of secondary sources and their systematic analysis.

In this study, we take an interdisciplinary approach, examining policy constraints and pedagogical strategies. Initially, we aimed to focus on a specific underrepresented identity group within South Dakota's engineering education landscape. However, a preliminary review of scholarly literature revealed insufficient research on any single group, necessitating a broader exploration of systemic barriers to inclusion. Additionally, given the current political landscape, we deliberately shifted our language from terms like *diversity* and *equity* to *inclusion*, as it is often perceived as a more neutral and policy-friendly term, particularly in education discussions related to disability accommodations. This broader scope allowed a more comprehensive understanding of how the state's policy restrictions shape institutional inclusion in engineering education. A narrowly focused study would risk overlooking critical intersections between policy and pedagogy that collectively influence the educational trajectories of engineering students.

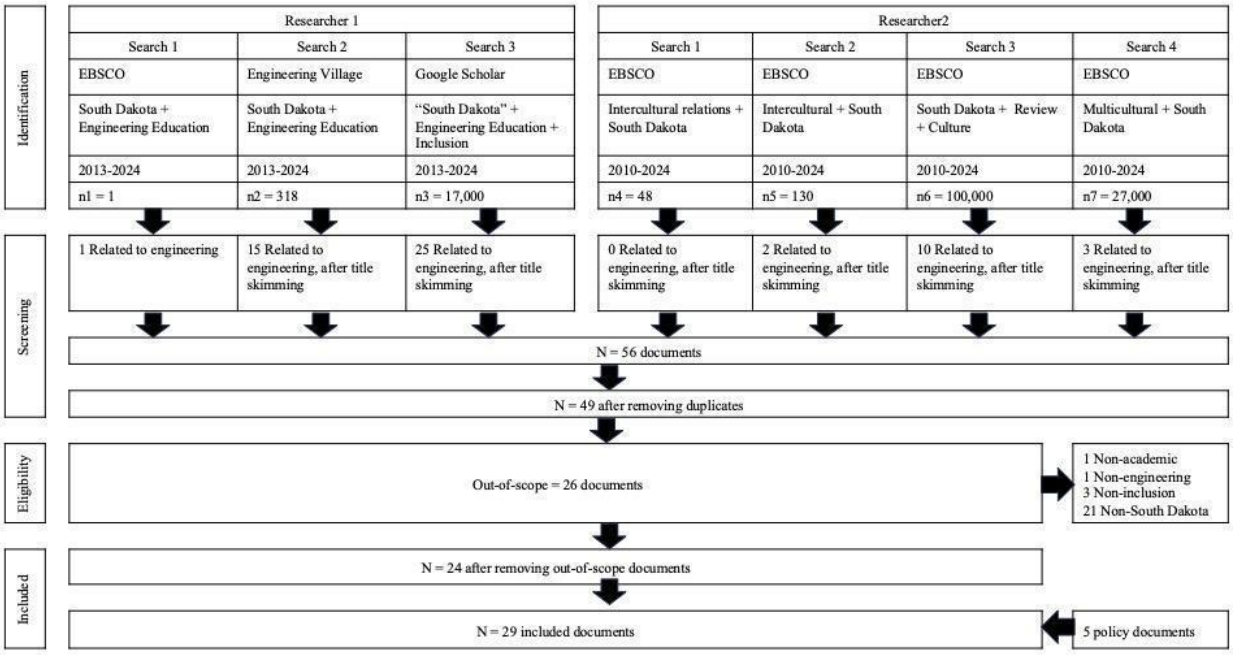
To address these questions, the study employed a systematic review process adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology. The PRISMA framework was selected for its rigor and transparency, making it widely applicable in academic and policy-driven reviews (Moher et al., 2009). This methodology encompasses four key phases: identification, screening, eligibility, and inclusion, ensuring that only relevant and high-quality documents contribute to the analysis (Figure 1).

The document identification phase involved extensive database searches, including EBSCO, Engineering Village, and Google Scholar. The search strategy incorporated diverse keyword combinations, such as "South Dakota," "Engineering Education," "Intercultural relations," and "Multicultural," to capture a broad spectrum of relevant literature. The search results varied significantly, with some queries yielding up to 100,000 documents, depending on the database and criteria applied. Articles were assessed for relevance to engineering education and inclusion during the screening phase. Titles and abstracts were initially skimmed, and the selection was refined to exclude non-relevant documents. This process reduced the dataset to 56 documents and filtered to 49 by removing duplicates. Eligibility criteria were applied to exclude out-of-scope, non-academic, non-engineering, or irrelevant documents to the study's focus on inclusion in South Dakota. Documents that failed to meet the rigorous criteria were excluded, leaving 23 articles for detailed evaluation. The inclusion phase yielded 29 documents, including five policy documents, which formed the core dataset for the systematic review.

This selection adhered strictly to the PRISMA guidelines, ensuring the reliability and relevance of the findings (Page et al., 2021).

Data analysis was conducted with a focus on answering the research questions. Thematic analysis was employed to identify recurring patterns and themes across the selected documents. This approach facilitated categorizing insights about advancements, practices, gaps, and constraints in inclusive engineering education. Using thematic analysis provided a structured framework for synthesizing diverse data sources and deriving meaningful conclusions (Braun & Clarke, 2006).

Figure 1.
PRISMA methodology application for the study.



Findings

Four central research questions have guided the analysis of inclusion in engineering education in South Dakota: How has inclusion in engineering education advanced in South Dakota over the last ten years? How has inclusion in engineering education been researched and implemented? What gaps and educational practices could hinder inclusivity in engineering education? What criteria constrain the design of inclusive educational programs and curricula in engineering education within South Dakota? The analysis revealed three major themes: Policy advancements, Research advancements, and Pedagogical advancements. These themes capture the multifaceted efforts to promote inclusion in engineering education, spanning state-level policies, academic research, and educational practices designed to create more equitable learning environments. Figure 2 illustrates the connection between the themes, codes, and the analyzed papers to provide a comprehensive overview of the findings.

Policy advancements.

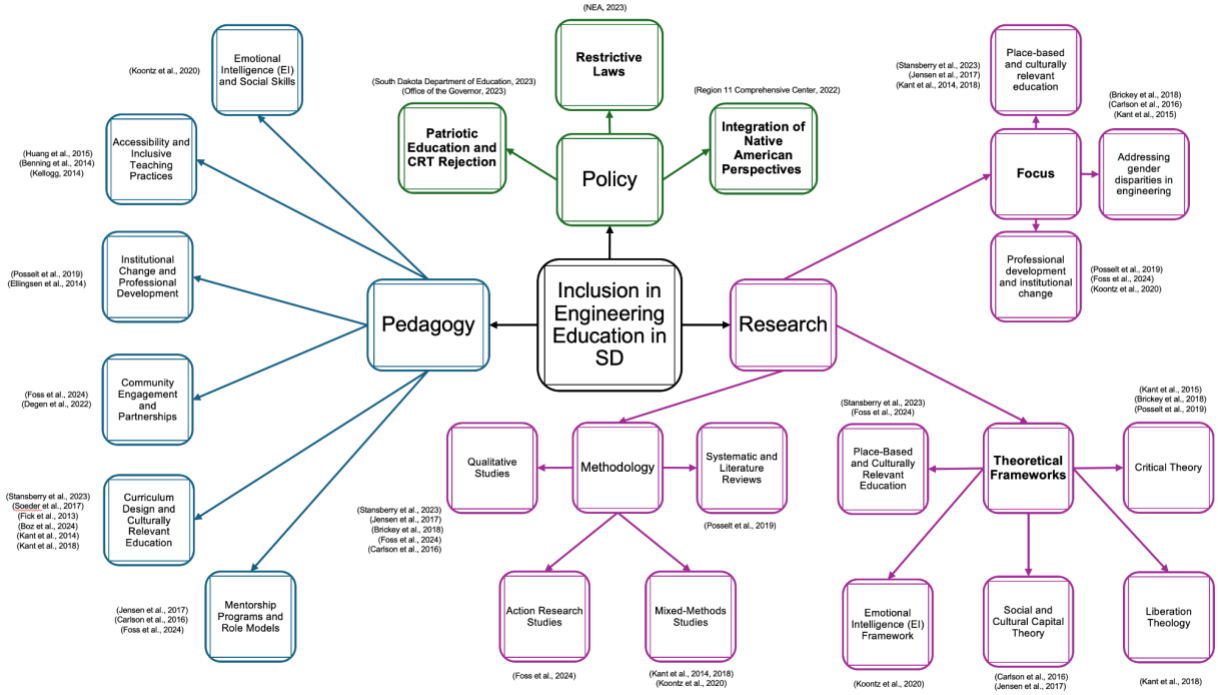
Over the last ten years, there has been little evidence of explicit advancements in policies related to inclusion in engineering education. However, policies in South Dakota often frame inclusion in education through a patriotic lens, actively rejecting frameworks such as Critical Race Theory (CRT) and systemic equity analyses. For example, the South Dakota Civics and History Initiative (South Dakota Department of Education, 2023) promotes patriotic education while avoiding critical engagement with systemic inequities. This initiative explicitly states that "CRT [Critical Race Theory] and similar

frameworks are divisive and do not align with South Dakota's values," which marginalizes the acknowledgment of diverse perspectives and experiences.

Additionally, while culturally responsive practices are encouraged, restrictive laws such as the "Divisive Concepts" Act create an environment that discourages educators from addressing race and inequities openly (NEA, 2023). For instance, the Know Your Rights policy guide from the National Education Association mentions that educators in South Dakota "face challenges when discussing topics of race due to fear of violating state-imposed restrictions" (NEA, 2023, p. 12).

Figure 2.

Concept map. Inclusion in Engineering Education in South Dakota.



Initiatives like the Oceti Sakowin Essential Understandings (OSEUS), which aim to integrate Native American perspectives, represent a positive effort but are hindered by insufficient resources and professional training (Region 11 Comprehensive Center, 2022). The report, Relighting the Fires for Standards Implementation in South Dakota, emphasizes that "teachers lack the necessary tools and confidence to fully integrate Native American histories and perspectives into their classrooms" (Region 11 Comprehensive Center, 2022, p. 7).

Policies prioritize workforce readiness over inclusivity, as reflected in directives from the Office of the Governor. A letter to the South Dakota Board of Regents specifies that "workforce development and collaboration with businesses must remain the primary focus, ensuring that educational programs align with market needs" (Office of the Governor, 2023, p. 2). Additionally, the exclusion of pronoun references undermines efforts to support underrepresented groups, particularly within gender-diverse communities.

Research advancements.

Eleven (45%) out of the twenty-four selected papers are focused on the inclusion of Native Americans in engineering, seven (30%) on women, four (17%) on underrepresented populations in general, and one (4%) on people with disabilities and first-generation. In summary, most of the studies are primarily focused on addressing the persistent underrepresentation of marginalized groups—particularly Native American, Indigenous, and female students—in engineering education.

To address this phenomenon, Stansberry et al. (2023) and Posselt et al. (2019) aimed to explore strategies for promoting inclusion by examining educational practices, mentorship programs, and outreach initiatives. Stansberry et al. (2023) conducted a systematic mapping study to evaluate place- and land-based learning approaches that integrate Indigenous cultural knowledge with STEM curricula in K-12 education. Their research highlighted the importance of culturally relevant teaching practices in fostering engagement among Indigenous students. Similarly, Posselt et al. (2019) focused on inclusion efforts in civil engineering geosciences. Their study examined the impact of the NSF-GOLD program, which aimed to increase diversity through professional development, leadership training, and institutional change. Other studies, such as those by Kant et al. (2014, 2018) and Jensen et al. (2017), focused on capacity-building programs and outreach efforts to increase STEM participation among Indigenous students. Kant et al. (2014, 2018) highlighted the importance of culturally responsive STEAM activities for Native American girls, integrating Dakota/Lakota values into STEM education. Jensen et al. (2017) focused on mentorship programs such as the Tiospaye initiative, which creates a supportive network for Native American students in engineering.

The papers draw on various theoretical frameworks to guide their research. One prominent framework was critical theory, which underpinned some studies, including those by Kant et al. (2015) and Brickey et al. (2018). These researchers used critical theory to challenge the structural inequalities perpetuating marginalized groups' underrepresentation in engineering. They argued that educational practices must be restructured to address the social, cultural, and economic barriers faced by Indigenous and female students. Another frequently used framework was liberation theology, particularly in studies emphasizing cultural pride and identity as essential education components. Kant et al. (2018) employed liberation theology to advocate for educational practices that empower Indigenous students by integrating their cultural values into STEM learning. This framework emphasized the importance of self-determination and cultural preservation in educational settings. Some other studies used social and cultural capital theory to explore how students' social networks and cultural backgrounds influence their educational experiences. Carlson et al. (2016) applied this framework to understand how mentorship programs can build cultural capital for Indigenous students, helping them navigate academic environments that may feel unfamiliar or unwelcoming. By building cultural capital, these programs helped students develop a sense of belonging and confidence in their academic abilities. Additionally, emotional intelligence (EI) frameworks were applied in studies such as Koontz et al. (2020), which focused on how emotional awareness and empathy can foster inclusive learning environments. The authors argued that developing students' emotional intelligence can improve their collaborative skills in group projects and help them navigate diverse teams more effectively.

The methodologies employed across the papers varied widely, reflecting the interdisciplinary nature of research on inclusive engineering education. Many studies adopted qualitative approaches to explore the experiences and perspectives of students and educators. For example, Stansberry et al. (2023) used a systematic mapping study to synthesize existing research on place- and land-based learning. Their methodology involved analyzing trends and patterns across a large body of literature to identify best practices in culturally relevant education. Similarly, Jensen et al. (2017) conducted qualitative interviews and focus groups with Native American students participating in the Tiospaye mentorship program. By gathering narrative data, they could explore students' personal experiences and identify the factors that contribute to their academic success. On the other hand, Brickey et al. (2018) conducted a case study of a mining engineering program to support women in a traditionally male-dominated field. By focusing on a single program, they could explore the nuances of its implementation and assess its effectiveness in promoting inclusion.

Other studies employed mixed-methods approaches. For example, Kant et al. (2018) used pre- and post-activity surveys alongside focus groups to evaluate the impact of culturally responsive STEAM activities on Native American girls. Their mixed-methods approach allowed them to quantify changes in student attitudes toward STEM while capturing rich, qualitative insights into how these activities influence students' cultural pride and engagement. Finally, some studies incorporated action research methodologies, where researchers collaborated with educators and community members to implement and

evaluate interventions in real-world settings. Foss et al. (2024) described an art and engineering outreach program that used participatory action research to engage students from diverse backgrounds. This approach ensured that the research was responsive to community needs and had a direct, practical impact on educational practices.

Pedagogical advancements.

The reviewed literature highlights how educational practices in South Dakota have evolved to promote inclusion through various pedagogical structures and curriculum designs. These efforts emphasize culturally relevant teaching strategies, mentorship programs, and community engagement initiatives to address systemic barriers faced by underrepresented groups, particularly Indigenous students. The papers analyzed demonstrate that inclusion in education can be achieved by integrating local culture, emotional intelligence, and professional development, creating pathways for Indigenous students and other marginalized populations to succeed in engineering.

Place- and land-based learning approaches have emerged as vital strategies for promoting culturally relevant STEM education among Indigenous students. Stansberry et al. (2023) emphasize the importance of collaborating with Native communities to design curricula integrating Indigenous knowledge systems with Western science principles. Programs like Native Earth | Native Sky (NENS) demonstrate how culturally responsive curricula can foster inclusion by incorporating traditional ecological knowledge and stories into K-12 STEM education. Similarly, community-based engineering (CBE) projects have effectively engaged Indigenous students by addressing local environmental and community issues. Soeder et al. (2017) describe geoscience projects in civil engineering in partnership with Native American communities, demonstrating how STEM education can be made more relevant by grounding it in students' lived experiences. Fick et al. (2013) also highlight using project-based learning in civil engineering capstone courses to engage Native American students, showing how place-based education promotes academic success and cultural pride. Programs in rural and Indigenous schools have further strengthened engineering pathways by incorporating culturally relevant projects. For example, Boz et al. (2024) describe technology-rich engineering experiences that combine traditional knowledge with modern STEM concepts, helping students see the relevance of engineering in their communities.

Mentorship and partnership programs and role models were essential pedagogical tools for improving the representation and retention of underrepresented students in STEM fields. The Tiospaye program at South Dakota Mines exemplified a successful mentorship model, creating a supportive network that offered academic, cultural, and financial support for Native American students (Jensen et al., 2017). This program fostered a sense of belonging and encouraged persistence in engineering education. Kant et al. (2015) emphasized the importance of providing culturally relatable role models for Indigenous students, particularly in fields like engineering. Similarly, Carlson et al. (2016) discussed how mentorship initiatives specifically aimed at women in STEM fields have helped increase enrollment and retention rates. On the other hand, the role of community partnerships was also critical. Foss et al. (2024) described outreach programs that engage local communities and tribal colleges to provide mentorship opportunities. Ellingsen et al. (2014) further highlighted the role of accessible instructional materials and accommodations in ensuring that diverse students can fully participate in STEM programs.

Several education practices in South Dakota *addressed systemic barriers* faced by Native American students by promoting *culturally relevant curricula*. Kant et al. (2014) described outreach programs that counteract challenges such as poverty and limited representation in STEM fields. These programs used hands-on activities, cultural storytelling, and exposure to STEM professionals to inspire interest in engineering careers. Degen et al. (2022) highlighted the importance of first-generation student programs like SD-FIRST, which provided targeted support for students facing financial and cultural barriers in higher education. Huang et al. (2015) highlighted the importance of addressing accessibility barriers in instructional materials to ensure that all students can participate fully in STEM programs. Benning et al. (2014) and Kellogg (2014) described similar approaches to creating inclusive classrooms by fostering intercultural competency and cognitive diversity.

Targeted *outreach programs* focusing on STEAM enrichment for Indigenous girls have shown promising results in fostering interest in STEM fields. Kant et al. (2018) described culturally responsive activities integrating Dakota/Lakota values with technical learning, such as traditional arts, crafts, and plant-based science experiments. These programs promoted cultural pride and boosted interest in STEM careers by showing Indigenous girls that their cultural identities can coexist with STEM pursuits. Foss et al. (2024) described how incorporating traditional arts into STEM activities has helped Indigenous students bridge cultural gaps and see themselves as part of the STEM community. Summer camps organized through the Pre-Engineering Education Collaborative (PEEC) initiative have also created pre-engineering pathways for Indigenous students. These camps emphasized experiential learning and mentorship, helping students transition into engineering programs (Kant et al., 2014).

Institutional change was also an important component of promoting inclusive education practices. Posselt et al. (2019) described efforts to foster inclusion within the geosciences through the NSF-GOLD (GEO Opportunities for Leadership in Diversity) program. This initiative provided professional development and leadership training to underrepresented groups, including women and Indigenous individuals. The program focused on bystander intervention training, network formation, and educating faculty to recognize and challenge academic exclusionary practices.

Finally, Koontz et al. (2020) further explored the role of *emotional intelligence (EI)* in fostering inclusive classroom environments. They described how project-based learning (PBL) can help students understand and manage their emotions during group work. This approach fosters empathy and collaboration, essential for creating inclusive learning environments. Educators can promote collaborative learning and create more inclusive spaces in engineering education by teaching students to manage their emotions and empathize with others.

Discussion

Efforts to promote inclusion and equity in STEM education in South Dakota reflect a combination of practical initiatives and policy-driven challenges. On the one hand, educational institutions have implemented mentorship programs, gender equity initiatives, and place-based learning approaches to improve engagement among underrepresented groups, particularly Native American and female students. On the other hand, systemic barriers such as ideological biases, restrictive policies, and resource limitations constrain inclusive curricula development. These dynamics reveal a complex interplay between progressive educational practices and institutional challenges, shaping the state's inclusivity of engineering and STEM programs.

Progress and Initiatives for Inclusion

The National Science Foundation (NSF) and U.S. Census Bureau data highlight significant disparities for underrepresented populations in engineering. For example, Native American students make up approximately 9% of South Dakota's population but remain disproportionately underrepresented in engineering fields (NSF, 2019). However, South Dakota's K-12 and Higher education sectors have continued to create opportunities for their student population through outreach & afterschool programs, educational investments, and apprenticeship programs in STEM-related career paths. For instance, the South Dakota DOE (2018) grant featured a diverse pool of students supporting 6,770 girls and 6,839 boys through various grade levels, races, and socioeconomic statuses. Serving 5,1230 American Indian students through various services and activities (South Dakota Department of Education, 2018) to help with academic enrichment, career and technical education, and attendance.

South Dakota has also seen targeted efforts to address the underrepresentation of Native American and female students in engineering through university-level programs and state policies. Recruitment and retention programs, particularly those focusing on culturally relevant education, have helped address educational disparities. Initiatives like the Tiospaye program at South Dakota Mines have successfully created supportive academic networks for Native students by providing mentorship, financial support, and community-based engagement (Ong et al., 2020). At the high school level, culturally responsive programs integrating art and traditional knowledge with engineering have effectively engaged

Native American girls (Whitcomb et al., 2021). These initiatives recognize the importance of cultural identity in fostering educational interest and retention in engineering. Moreover, place-based learning programs emphasize connecting educational content to local environments and Indigenous knowledge systems, making engineering education more relevant and meaningful for Native students (Hartman et al., 2019).

In addition to Native-focused efforts, gender equity initiatives have been implemented across South Dakota Board of Regents (SDBOR) universities. These programs have focused on increasing female enrollment and retention in traditionally male-dominated fields, such as engineering and geosciences. They have done so through curriculum modifications, mentorship, scholarships, and professional development programs (Waychal et al., 2018). However, findings suggest that gender disparities remain persistent, particularly in faculty hiring, retention, and salary equity (Equity Action Plan, 2022).

Efforts to integrate emotional intelligence (EI) into engineering programs have also proven beneficial. By addressing cognitive diversity and inclusive team collaboration, some institutions are making strides toward creating more inclusive educational environments that recognize diverse learning styles (Holly Jr. et al., 2022).

Challenges and Constraints in Inclusive Program Design

Despite these initiatives, several constraints hinder the design and implementation of inclusive educational programs in South Dakota. Policy restrictions, including ideological biases and workforce-centric educational priorities, have created significant barriers to curricular innovation. For instance, patriotic education mandates and anti-CRT policies discourage educators from engaging in critical discussions on diversity and equity, limiting the scope of inclusive curricula (Whitcomb et al., 2021).

Moreover, lack of funding and professional support further constrains the integration of Native American-focused standards into educational programs (Hartman et al., 2019). Programs that rely on external grants often struggle with sustainability once the funding ends (Ong et al., 2020). Frequent turnover in university leadership positions, particularly among provosts and faculty, has also led to inconsistencies in implementing policies promoting inclusion (Waychal et al., 2018).

Structural challenges within engineering education are another major constraint. Traditional engineering curricula prioritize technical content over social and cultural awareness, leaving students ill-prepared to address diversity and inclusion in their future careers (Holly Jr. et al., 2022). The gatekeeping practices of faculty and administrators, who control key processes like admissions, hiring, and promotions, further limit inclusivity by perpetuating existing biases within the field. Low enrollment numbers in smaller programs, such as mining engineering, make it challenging to scale inclusive initiatives or incorporate innovative approaches (Equity Action Plan, 2022).

Additionally, cultural misalignment between standardized engineering curricula and Indigenous values presents a significant barrier for Native students. Schools often lack Indigenous educators and role models, and educators may not receive adequate training in culturally responsive pedagogy, limiting their ability to design inclusive curricula (Whitcomb et al., 2021; Ong et al., 2020). This misalignment reinforces preconceptions of engineering as disconnected from community-centric values, further deterring Indigenous students from pursuing an engineering career.

Local vs national perspectives on inclusion in engineering education.

The systemic barriers to inclusive education in engineering education in South Dakota must be understood as part of broader social and political structures that perpetuate inequality and oppression. These barriers manifest through rigid curricular structures, faculty biases, and exclusionary institutional practices.

First, the Supreme Court's 2023 ruling on affirmative action can be seen as a reinforcement of what South Dakota's Governor expressed in the letter by implicitly supporting some populations within educational institutions and maintaining privilege for dominant groups while further marginalizing historically excluded communities (Rodriguez et al., 2022). Andrews and Boklage (2024) argue that such

rulings disrupt long-standing diversity efforts, forcing universities to adopt race-neutral strategies that fail to address underlying inequalities. Second, the restrictive policies enacted in states like Florida reflect a national ideological backlash against diversity and inclusion rooted in conservative fears of social change. These policies aim to maintain the status quo by silencing discussions about race, gender, and systemic inequalities, effectively erasing the historical and cultural experiences of marginalized groups from educational content (Pearson et al., 2022; Paris, 2024).

Despite the efforts to hinder diversity in engineering, it has been demonstrated that workforce diversity drives innovation and economic growth. Research shows that diverse teams produce better engineering solutions by integrating multiple perspectives (Hong & Page, 2004). From this perspective, addressing inclusion in engineering education aligns with South Dakota's economic development goals, particularly in industries like infrastructure, renewable energy, and manufacturing, which require a skilled and diverse STEM workforce.

Successful national programs offer valuable models for South Dakota. For instance, the National Science Foundation's ADVANCE program has aimed to increase the representation of women and minorities in STEM through leadership development and institutional transformation (Golden, 2024). Similarly, the Louis Stokes Alliances for Minority Participation (LSAMP) program has focused on increasing the number of underrepresented students earning degrees in STEM by providing mentorship, research opportunities, and financial support (Mejia et al., 2018). Another example is the Mathematics, Engineering, and Science Achievement (MESA) program in California, which has successfully increased the participation of underrepresented students in STEM by offering tutoring, leadership development, and internship opportunities (Cochran & Boveda, 2020). Lessons from these programs indicate that institutional commitment, mentorship programs, and faculty training are key to fostering inclusive engineering education. South Dakota institutions could adopt elements of these programs within existing legal and funding constraints by prioritizing professional development for educators, leveraging partnerships with tribal colleges, and integrating mentorship initiatives.

A possible roadmap curriculum design for inclusion in South Dakota

To strengthen engineering education in South Dakota while aligning with current policy and funding realities, K-12 and higher education educators should emphasize workforce readiness, student success, and industry collaboration rather than traditional diversity-focused initiatives. A key adjustment is the intentional shift in language to ensure alignment with state and federal education priorities. Rather than framing efforts around diversity, equity, and inclusion (DEI), educators can use terms such as *student achievement and retention*, *workforce preparedness*, *career pathways*, and *technical excellence*. This strategic language shift might ensure continued institutional support while maintaining a focus on expanding access to engineering education for all students. K-12 educators may prioritize early exposure to engineering through problem-solving activities tied to South Dakota's economic needs, such as agriculture, energy, and infrastructure development. Collaborations with businesses and technical colleges can provide apprenticeships, industry-backed engineering challenges, and STEM career preparation programs that remain politically and financially sustainable. High school educators can promote dual-credit and technical certification programs that offer students direct entry points into engineering and STEM careers without relying on politically contested funding streams.

Higher education engineering educators can focus on industry-aligned curricula, student retention, and sustainable funding to ensure program growth while adapting to current policies. Embedding hands-on, workforce-driven experiences through internships, employer-sponsored projects, and applied learning will strengthen career readiness. To improve retention, universities should implement peer mentorship, academic coaching, and faculty-led engineering workshops that reinforce technical skills. Informal learning pathways, such as engineering boot camps and community-based design challenges, can expand engagement without relying on DEI initiatives. Financial sustainability should come from private-sector partnerships, alumni-backed scholarships, and industry sponsorships, reducing dependence on federal funding. By framing inclusion as workforce development and

institutional excellence, engineering programs can continue to attract, support, and graduate highly skilled engineers who drive South Dakota's economy.

In addition to formal education, informal learning environments are crucial in increasing engineering engagement and broadening participation without triggering funding constraints. Engineering educators should leverage after-school programs, community-based maker spaces, robotics clubs, and STEM summer camps to expose students to hands-on learning outside traditional classrooms. Libraries, science museums, and workforce development centers can be accessible entry points for students—particularly those from rural or economically disadvantaged backgrounds—to gain engineering experience without requiring institutional DEI programs. Higher education faculty can collaborate with local organizations and industry partners to create extracurricular engineering workshops, open-access skill-building courses, and community-driven engineering challenges that prepare students for technical careers. These informal education strategies provide scalable, cost-effective solutions to sustain student engagement in engineering. By reframing inclusion as an investment in workforce competitiveness, technical innovation, and institutional excellence, engineering educators can continue expanding access to engineering careers while ensuring alignment with the current educational policies and funding structures.

Conclusions

The efforts to promote inclusion in South Dakota's engineering education system demonstrate significant progress and persistent challenges. Initiatives such as mentorship programs, place-based learning, and gender equity efforts have addressed educational disparities. However, systemic barriers—including restrictive policies, limited resources, and cultural misalignments—continue to hinder the effectiveness and sustainability of these efforts. Ensuring inclusive educational environments requires a holistic approach combining policy reform, professional development, community engagement, and curriculum innovation.

Efforts to promote inclusion in engineering education must begin by addressing the unique demographic and cultural characteristics of South Dakota. These efforts should prioritize equity for Indigenous communities, including Dakota, Nakota, and Lakota peoples, while also recognizing the growing Latinx and international student populations. Future policies and programs should create spaces where students, staff, and faculty from diverse backgrounds feel a sense of belonging and support within their academic environments.

South Dakota's initiatives, such as the Tiospaye program and Native Earth | Native Sky, have laid important groundwork for culturally responsive engineering education. However, these programs require continued investment and statewide coordination to ensure sustainability and scalability. Integrating successful national models, such as the National Science Foundation's ADVANCE program and the Louis Stokes Alliances for Minority Participation (LSAMP), into South Dakota's context would provide additional recruitment, retention, and professional success pathways for underrepresented students.

Achieving lasting progress in inclusive engineering education requires action across three key areas: policy, research, and pedagogy. Policy advancements should aim to remove restrictive regulations that limit discussions on diversity, equity, and inclusion (DEI). Additionally, state policies should promote sustained funding models to ensure that inclusive programs can thrive beyond their initial grant cycles. These policies must recognize the importance of DEI initiatives at both K-12 and higher education levels, ensuring that students from diverse backgrounds encounter inclusive environments throughout their educational journeys.

In terms of research, there is a need for continued investigation into the barriers faced by underrepresented groups in engineering education. Research should explore intersectional challenges, particularly for Native American women and students from rural communities, to better understand how multiple identities impact their educational experiences. Furthermore, research should guide the development of effective strategies for integrating cultural relevance into engineering curricula, ensuring that these programs reflect the values and knowledge systems of the communities they serve.

Pedagogical advancements are equally essential. Educators should receive professional development to help them incorporate culturally responsive teaching practices into their courses. Place-

based learning, emotional intelligence frameworks, and community engagement projects are promising approaches that can make engineering education more inclusive. Universities should also adopt project-based learning models that allow students to apply their technical knowledge to real-world problems relevant to their local communities.

Finally, future work must prioritize the creation of inclusive environments for staff and faculty. Ensuring diverse faculty members feel a sense of belonging and support is essential for fostering inclusive academic spaces. This involves addressing hiring practices, promotion pathways, and workplace cultures, which often exclude or marginalize women and people of color in academia.

Advancing inclusive engineering education in South Dakota requires a comprehensive strategy that addresses policy, research, and pedagogy. By adapting successful national models, investing in sustainable programs, and fostering inclusive environments for students and faculty alike, South Dakota can create a more equitable educational landscape that reflects the diverse identities of its communities.

References

ASEE (2020). Engineering & engineering technology by the numbers.

Basile, K. C., & Beauregard, R. J. (2016). Challenges and mental health in marginalized engineering students. Journal of Engineering Education.

Brickey, A., McCormick, K., Jensen, P., & West, M. (2018). Changing the culture and attitude: Supporting women studying mining engineering. International Journal of Georesources and Environment, 4(3), 169–173.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.

Campbell, D. E., Smith, N., & Chapman, R. (2018). Teamwork and interpersonal skills for engineers. Engineering Education Research Journal.

Equity Action Plan. (2022). Fostering equity and inclusion in the Penn State College of Engineering.

Foor, C. E., Walden, S. E., & Trytten, D. A. (2007). "I wish that I belonged more in this whole engineering group": Achieving individual diversity. Journal of Engineering Education, 96(2), 103–115.

Gonzalez, J., & Wagenaar, R. (2003). Tuning educational structures in Europe: Final report. Publicaciones de la Universidad de Deusto.

Grand, M. & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. Health Information and Libraries Journal, 26, 91-108.

Hartman, H., Forin, T., Sukumaran, B., & Farrell, S. (2019). Strategies for improving diversity and inclusion in an engineering department. Issues in Engineering Education.

Holly Jr., J., Hira, A., Maxey, K., & Beebe, C. (2022). Who gets to engineer? Countering the mythology of inclusion in American engineering education.

Hong, L., & Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. Proceedings of the National Academy of Sciences, 101(46), 16385–16389.

Joubert, Y. T., et al. (2020). Intercultural competencies in engineering education. Global Perspectives on Engineering Education.

Kellogg, S. (2014). Building diversity by embracing intellectual diversity. IEEE. https://doi.org/10.1109/FIE.2014.7044048

Lord, S. M., et al. (2019). The role of inclusion in STEM education. ASEE Annual Conference Proceedings.

Mapping Your Future (2025). School Profile: South Dakota School of Mines and Technology. Retrieved from https://southdakota.mappingyourfuture.org/school_profile.cfm?code=sd&calcs&page=0&s=SD&t=&size=&sort=gr&ID=219347&level=1.

McGee, E. O. (2020). Intersecting identities in engineering: A critical analysis of women of color in engineering.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLOS Medicine, 6(7), e1000097.
National Academies of Sciences, Engineering, and Medicine. (2017). Increasing diversity in the STEM workforce. Washington, DC: National Academies Press.
National Center for Education Statistics (NCES). (2021). Condition of education: STEM degrees by demographics.
National Education Association (NEA). (2023). Know your rights: South Dakota.
National Science Foundation. (2019). Women, minorities, and persons with disabilities in science and engineering: 2019. NSF Report.
National Science Foundation. (2020). Bridging the gap: Tribal colleges and STEM pathways. NSF Reports.
Office of the Governor, South Dakota. (2023). Letter to the South Dakota Board of Regents.
Ong, M., Jaumot-Pascual, N., & Ko, L. T. (2020). Research literature on women of color in undergraduate engineering education: A systematic thematic synthesis. Journal of Engineering Education.
Page, M. J., McKenzie, J. E., Bossuyt, P. M., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71.
Posselt, J. R., Chen, J. A., Dixon, G., Jackson, J. F. L., Kirsch, R., Nuñez, A.-M., & Teppen, B. J. (2019). Advancing inclusion in the geosciences: An overview of the NSF-GOLD program. Journal of Geoscience Education, 67(4), 313-319.
Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. Journal of Engineering Education, 95(2), 123–138.
Region 11 Comprehensive Center (R11CC). (2022). Relighting the fires for standards implementation in South Dakota.
Seymour, E., & Hewitt, N. M. (1997). Talking about leaving: Why undergraduates leave the sciences. Boulder, CO: Westview Press.
Smith, L., et al. (2018). Place-based education in STEM: Integrating Indigenous knowledge systems. STEM Education Review.
South Dakota Board of Regents (2023). Factbook. Fiscal year 2023. Office of the Executive Director.
South Dakota Department of Education. (2023). Good citizenship and the true and inspiring story of America: A critical policy analysis of the South Dakota civics and history initiative.
South Dakota Department of Education (2018). *21st Century Community Learning Centers: 2018 South Dakota Statewide Evaluation Summary*. South Dakota Department of Education, 2018,
South Dakota Mines (2022). The Tiospaye program: Supporting Native students in STEM. South Dakota Mines Publications.
South Dakota Mines (2023). Tabular Data for Academic Year Enrollments. Retrieved from https://public.tableau.com/app/profile/sdmines.institutional.research/viz/Enrollments_16881438532410/Enrollments.
Waychal, P. K., Henderson, C., & Collier, D. (2018). A systematic literature review on improving the success of women engineering students in the U.S.
Whitcomb, K. M., Maries, A., & Singh, C. (2021). Examining gender differences in a mechanical engineering and materials science curriculum. International Journal of Engineering Education.