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Measuring the Integration of Diversity Equity and Inclusion Principles in Engineering Teaching Practices in Select PWI and HBCU

Dr. Oludare Adegbola Owolabi P.E., Morgan State University

Dr. Oludare Owolabi, a professional engineer in Maryland, joined the Morgan State University faculty in 2010. He is the Director of the Sustainable Infrastructure Development, Smart Innovation and Resilient Engineering Research Lab Department of Civil and Environmental Engineering

Jennifer Cromley

Jennifer Cromley is Professor of Educational Psychology at the University of Illinois at Urbana-Champaign. Her research focuses on two broad areas: achievement/retention in STEM and comprehension of illustrated scientific text

Blessing Isoyiza ADEIKA, Morgan State University

Blessing ADEIKA is a graduate student at Morgan State University currently studying Advanced Computing. She has interest in teaching student basic concepts by adopting an Experiment-centric approach to it. She also is currently working towards being a Data Scientist - AI/ML Expert and hope to use her skills to prefer solutions in the Medical, Financial, Technology and any other Sector she sees a need to be filled/catered for.

Raymond Deji Olamijulo, Morgan State University

Mr Raymond Olamijulo is a graduate assistant in the Computer Science department at Morgan State University. With a research focus on experiment-centric pedagogy in engineering education, Mr. Olamijulo has contributed to advancing both theoretical and practical aspects of engineering education and technology integration in the curriculum.

Mr Olamijulo holds a B.Sc. in Information and Communication Technology from Crawford University. He also holds a Masters degree in International MBA from Ulyanovsk State University. He has been a part of multiple international conferences promoting technological advancements.

In addition to his academic work, Mr Olamijulo is committed to enhancing the educational experience of undergraduate and graduate students through innovative teaching strategies and hands-on projects. He is actively involved in advising student projects, mentoring research groups, promoting hands-on learning experiences and is dedicated to fostering diversity and inclusion in the engineering field.

Dr. Blessing Funmbi Sasanya, Morgan State University

Dr. Blessing Funmbi Sasanya is a scholar in water resources and environmental engineering, specializing in hydrology, climate science, and sustainable water management. He is a Postdoctoral Research Associate in Civil and Environmental Engineering at Morgan State University. His expertise includes watershed hydrology, modelling (using statistical, physical based and Machine learning algorithms) and environmental monitoring, with applications in water scarcity mitigation, agricultural productivity, and climate resilience. Dr. Sasanya has published widely in international journals, contributing to advances in rainfall probability models, hydroclimatic trend analysis, and hydrological modeling. By integrating statistical, remote sensing, and modeling approaches, he fosters multi-disciplinary collaborations for wetlands and waterways mitigation forecasting. His academic trajectory demonstrates strong intellectual merit through methodological innovation and broad impacts in advancing sustainable environmental systems .

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Abstract

The integration of Diversity, Equity, and Inclusion (DEI) principles in engineering education is increasingly essential for training engineers to address complex global challenges. These principles foster environments and spaces that respect and support all learners to fully and independently engage and contribute. Despite the widespread advocacy for this pedagogy, the extent to which DEI principles are explicitly embedded in training remains under-examined, particularly across different institutional contexts. This study was designed to investigate current states of DEI integration in engineering lectures in select Predominantly White Institution (PWI) and a Historically Black College and University (HBCU). A qualitative content analysis approach was employed using 20 recorded engineering courses lecture videos originating from both institution categories, spanning a minimum of one hour each. Each lecture video was systematically coded using a DEI observation framework that captured indicators such as DEI in content delivery by instructors, DEI in giving instructions on assignment and assessment as well as DEI in oral communications during lectures. All results from the study were analyzed using descriptive statistics, chi-square and percentage changes. Findings from this study suggest notable variation in how DEI is represented across institutional types. The deliberate incorporation of DEI in engineering training and teaching practices can strengthen classroom inclusivity and student engagement, sense of belonging, and career readiness. By empirically comparing PWIs and HBCUs, this research contributes to the growing discourse on inclusive engineering education and provides a framework for institutional policy and faculty training programs which can advance equity and representation in the engineering field of practice.

Keywords: Lecture videos; Learning pedagogy; Positive DEI indicators; Negative DEI indicators

Introduction

The integration of Diversity, Equity, and Inclusion (DEI) principles into engineering education has become increasingly critical as institutions prepare students to navigate diverse professional environments and address complex global challenges [1, 2]. DEI is a framework that promotes representation, fair access to opportunities and resources, and the creation of environments where all individuals are respected, supported, and able to participate fully. DEI-oriented pedagogy creates learning spaces that respect, support, and empower all learners to contribute meaningfully, thereby enhancing engagement, persistence, and a sense of belonging among underrepresented groups. Within the engineering profession where rigid curricular structures, technical norms, and historical underrepresentation persist, the classroom is a potentially powerful site for advancing equity through inclusive teaching practices. Although calls for equity-minded instruction have intensified, the degree to which DEI principles are systematically embedded in engineering teaching remains poorly understood, especially when examined across differing institutional contexts [3].

Engineering programs at Predominantly White Institutions (PWIs) and Historically Black Colleges and Universities (HBCUs) operate within distinct demographic, historical, and cultural frameworks that may influence how DEI principles are interpreted and implemented. While HBCUs are widely recognized for fostering culturally affirming learning environments [4, 5], PWIs have made significant institutional commitments aimed at increasing diversity and

promoting inclusivity [6]. However, despite these differentiated missions, there is a lack of empirical research that directly compares how engineering instructors at these institutions integrate DEI into everyday teaching behaviors, communication styles, assessment practices, and content delivery. Much of the existing literature centers on institutional policies, climate surveys, or faculty perceptions, leaving a gap in understanding how DEI principles manifest within actual teaching practices observable in real classroom settings.

Recent scholarship has increasingly examined how DEI dynamics shape the experiences and trajectories of students in engineering and related STEM fields. Aufderheide et al. [7] demonstrated that cross-institutional online collaborative instruction between a Minority-Serving Institution (MSI) and a PWI can broaden pedagogical perspectives by motivating instructors to adopt new tools, projects, and assessments that strengthen culturally responsive engineering ethics education. Complementing this institutional lens, Clayton et al. [8] provided a nuanced account of Black first-year students' college choice processes, showing how family, school, community, institutional characteristics, and broader sociocultural forces collectively inform decisions to attend either HBCUs or PWIs. Their findings align with Hossler and Gallagher's three-phase model and Perna's four-layer framework. It further revealed that affordability, campus culture, geographic location combined with the growing role of digital resources and social media frequently shape final enrolment decisions, sometimes even overriding students' initial institutional preferences.

Wu et al. [9] further underscored persistent systemic gaps by documenting limited DEI representation in engineering curricula, textbooks, and student organizations in a Southern public university. Their survey and interview data highlighted disparities in belonging, with women and non-Caucasian students reporting lower inclusion and greater exposure to bias, thereby reaffirming the need for intentional DEI integration across academic and professional engineering environments. Extending this body of work, Berhan et al. [10] compared the racial and engineering identity formation of African American engineering students at an HBCU and a PWI, revealing that HBCU students experienced cultural congruence and comfort. However, for PWI students although expressing racial pride, remained acutely aware of their minority status and the need to navigate racialized perceptions. Across both contexts, professional organizations such as NSBE emerged as critical structures for fostering belonging, professional identity, and access to internships and career pathways. Collectively, these studies illustrate the complex interplay between institutional context, identity development, and structural inclusivity, and highlight enduring opportunities to strengthen DEI-driven transformation within engineering education.

From the forgoing review, several research gaps underscore the need for this present study. First, most studies rely on self-reported practices which may not reflect actual behavior while limited empirical studies employ direct observation such as classroom video analysis to measure DEI integration in engineering instruction. Second, comparative studies between PWIs and HBCUs remain scarce, despite their potential to illuminate institutional strengths, constraints, and pedagogical differences. Third, current DEI research in engineering often lacks frameworks tailored to the disciplinary nuances of engineering education, where team-based learning, problem-solving norms, and communication practices may influence inclusivity. The there are minimal studies documenting the specific DEI indicators that appear in lecture content, assignment instructions, verbal communication, or instructor–student interactions,

creating a substantial gap in evidence-based strategies for improving inclusive engineering pedagogy.

Furthermore, as national bodies such as ABET and ASEE increasingly emphasize inclusive, student-centered engineering instruction, the absence of rigorous evidence on how DEI principles are operationalized in real teaching contexts represents a critical gap. This study was therefore motivated by the need to systematically document and compare DEI integration in engineering teaching across contrasting institutional environments, using direct observation to generate actionable insights that can strengthen inclusive pedagogical practices, inform faculty development, and support more equitable engineering education outcomes.

This study addresses these gaps by systematically analyzing engineering lecture videos from selected PWIs and an HBCU using a structured DEI observation framework. The study aims to evaluate the extent to which DEI principles are present in engineering content delivery, assessment instructions, and classroom communication. Three research questions guide the investigation: (i) To what extent do engineering instructors integrate DEI principles into their teaching practices in selected PWI and an HBCU? (2) How do DEI-informed teaching practices differ across these institutional types? and (3) Which elements of DEI are most and least represented in observed engineering lectures? To answer these questions, the study employs qualitative content analysis supported by descriptive statistics to compare DEI patterns across institutions. The objectives of this study include (i) to document the presence of DEI indicators in engineering lectures; (ii) to compare the integration of DEI practices between PWIs and an HBCU; (iii) to identify areas of strong DEI-aligned pedagogy. By grounding the analysis in real classroom practices, the study provides empirical insights that transcend institutional rhetoric and highlight the pedagogical behaviors that shape inclusive engineering learning environments.

The implications of this work extend beyond the participating institutions. By offering a replicable framework for evaluating DEI integration in engineering instruction, the study informs efforts to enhance teaching effectiveness, refine accreditation processes, strengthen culturally responsive engineering education, and institutionalize inclusive pedagogical practices. The comparative perspective between PWIs and an HBCU contributes to a deeper understanding of how institutional context shapes DEI implementation and also promote cross-institutional learning and collaboration. Ultimately, the study provides a data-driven foundation for building more equitable engineering programs that support representation, belonging, and career readiness for all students.

Background of the Study

The growing national attention to DEI in science and engineering has underscored the need for teaching practices that actively promote equitable learning environments [1, 11], yet little empirical work has examined how DEI principles are enacted within actual engineering classrooms. Engineering education faces persistent disparities in student engagement, retention, and representation, particularly among historically marginalized groups, despite institutional commitments to broaden participation [12, 13]. PWIs and HBCUs operate within different historical and cultural traditions that shape their approaches to fostering inclusive learning [14], but existing scholarship largely focuses on institutional policies and student demographics rather than observable pedagogical behaviors [15].

Conceptual Framework

This study is guided by an integrated conceptual framework combining principles of inclusive pedagogy, culturally responsive teaching, and equity-centered engineering education [16]. Together, these position classroom instruction as a critical mechanism for advancing DEI in engineering programs. Inclusive pedagogy emphasizes instructional practices that acknowledge learner diversity, foster belonging, and remove barriers to participation [17]. Culturally responsive teaching highlights the importance of drawing on students' cultural backgrounds, lived experiences, and identities to enrich learning [18]. In the same vein, equity-centered engineering education promotes the intentional design of learning environments that mitigate structural inequities and broaden participation in the field [19]. Within this framework, DEI integration is conceptualized along three observable domains: (1) DEI in content delivery, which captures the degree to which instructors embed inclusive examples, contextualize engineering problems in culturally relevant ways, and avoid marginalizing language; (2) DEI in assessment and assignment instructions, which reflects transparency, accessibility, and equitable expectations for student performance; and (3) DEI in verbal and interactional communication, which encompasses instructor tone, respectfulness, affirmation of student contributions, and responsiveness to diverse perspectives.

Institutional context, specifically differences between PWIs and HBCUs is treated as an influential factor that shapes how these domains manifest, given variation in institutional missions, student demographics, and historical commitments to equity [20]. By linking these theoretical constructs with observable teaching behaviors, the framework provides a structured lens for analyzing how DEI principles are operationalized in engineering classrooms and enables a comparative evaluation of their representation across institutional types. Ultimately, this conceptual grounding positions DEI as both a pedagogical practice and a measurable instructional outcome, informing the study's coding protocol, analytical approach, and interpretation of findings. Figure 1 summarizes the conceptual framework of this study.

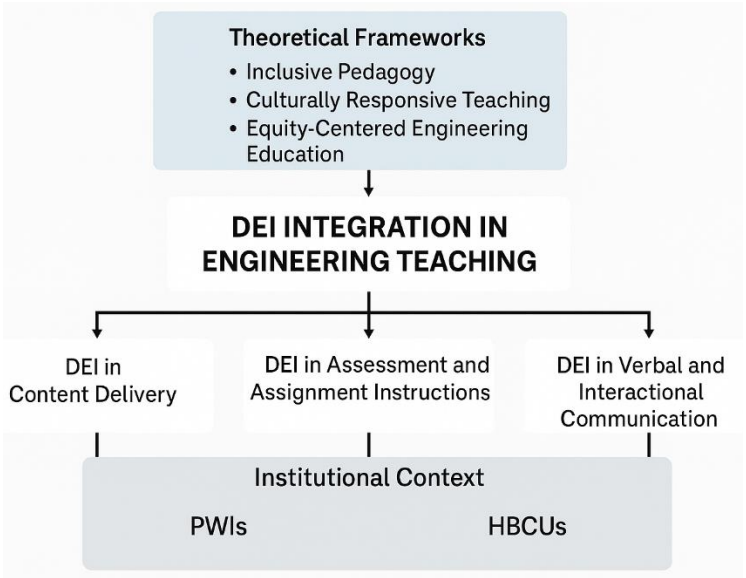


Figure 1: Conceptual Framework on the comparison of DEI Integration in Engineering Teaching Practices of PWIs and HBCUs

Methods

This study employed a qualitative content analysis design to systematically examine the degree to which DEI principles were integrated into engineering teaching practices across two institutional contexts: a PWI and a HBCU. The methodological approach was intentionally structured to enable reproducibility through clear documentation of sampling, data collection procedures, coding frameworks, analytical strategies, and trustworthiness measures.

Data Source and Sampling Procedure

The dataset consisted of 20 recorded engineering lecture videos, each a minimum of 60 minutes in duration, representing undergraduate engineering courses taught at one PWI (n = 10) and one HBCU (n = 10). Videos were sourced from instructor's after giving their consents. To ensure equitable representation across both institutions, lectures were selected from various engineering departments and subfields. Videos that contained incomplete audio, contained non-instructional content, or were shorter than one hour were excluded. Each lecture was assigned a unique identifier such as (PWI_01, HBCU_04) to ensure anonymity and to maintain traceability throughout the coding process.

Development of the DEI Observation Framework

The DEI observation protocol developed by the Developing Equity-Minded Engineering Practitioners (DEEP) of University of Illinois Urbana-Champaign and adopted by [21] was adopted in this study. Data analysis was guided by a structured DEI Observation Framework developed from three theoretical pillars: inclusive pedagogy, culturally responsive teaching, and equity-centered engineering education. The final coding scheme consisted of three major DEI categories, each with multiple sub-indicators. The indicators include:

i. DEI in Content Delivery: (a) Use of diverse examples and culturally relevant contexts (b) Avoidance of exclusionary or biased language (c) Integration of societal, ethical, or community-relevant engineering applications;
ii. DEI in Assignment and Assessment Instructions (a) Clarity and transparency of instructions (b) Efforts to support varied learning needs (c) Provision of equitable expectations and guidance;
iii. DEI in Verbal and Interactional Communication (a) Respectful, supportive instructor tone (b) Affirmation of student contributions (c) Encouragement of diverse perspectives (d) Demonstration of approachability and care.

Coding and Analysis Procedures

A directed content analysis approach was adopted to enable the systematic identification of DEI indicators. Two trained coders independently analyzed the videos using qualitative analysis software). To ensure replicability, coders followed a standardized protocol which involved viewing each full lecture twice for general familiarization with teaching flow and afterwards for the line-by-line coding of DEI indicators.

The coders applied one or more DEI codes to the verbal and visual segments that met operational definitions. The also recorded timestamps and scene descriptions to ensure transparency and auditability. Coded occurrences for each indicator and category were thereafter summarized. Discrepancies were resolved through collaborative discussion and refinement of coding rules.

Quantitative Descriptive Analysis

Although the study employed qualitative coding, occurrences of DEI indicators were quantified to facilitate comparison. For each video, the number of coded indicators within each DEI category was tallied. Institutional-level means and ranges were calculated for total DEI indicators per lecture, distribution across the three DEI categories, relative emphasis on content delivery, assessment and communication. These descriptive statistics provided an empirical basis for identifying institutional differences.

Limitations

Although this study makes significant contributions to engineering education, yet some limitations should be considered. First, the dataset consisted of 20 recorded engineering lectures from one PWI and one HBCU, which, while sufficient for qualitative content analysis, limits the generalizability of the findings to other institutions with different cultures, demographics, or instructional norms. The purposive sampling strategy prioritized diversity in course level and teaching style, yet the sample may not fully capture institutional variability or represent the full spectrum of engineering pedagogy across departments. Another limitation relates to the scope of the DEI Observation Framework itself. Although grounded in established pedagogical theory, the framework emphasizes observable behaviors and may not fully capture instructors' underlying intentions, planning processes, or non-visible efforts to promote equity, such syllabus design, out-of-class mentoring, assessment policies, or course restructuring. The coding process, while supported by intercoder reliability measures, still requires subjective judgment, and some DEI indicators may manifest differently across disciplinary contexts or instructor communication styles.

Finally, institutional context was treated as a categorical comparison (PWI vs. HBCU), which, while analytically useful, simplifies the complexity of institutional histories, student populations, and structural conditions that shape teaching practices. Future research using larger, multi-institutional samples, mixed-methods designs, or longitudinal data could provide deeper insights into how DEI is embedded across engineering programs and how instructional practices evolve over time.

Results

Results from this study are organized around the three research questions earlier mentioned. These also serve as thematic anchor. The results are grounded in systematic coding of classroom observations, with frequencies of positive and negative DEI indicators summarized in Figures 2 a and b. They provide empirical snapshots of how DEI principles are enacted in real engineering classrooms across institutional contexts.

Extent of Integration of DEI Principles in Engineering Lectures

The findings indicate that DEI principles are present in engineering teaching practices at both the HBCU and PWI. Although the extent and balance of positive versus negative indicators vary. Across institutions, instructors demonstrated multiple behaviors aligned with inclusive pedagogy, such as transparent teaching practices, acknowledgment of student contributions, and openness to multiple explanations or solutions. At the same time, observations also captured instances of practices that may undermine DEI goals, including assumptions about students, limited accessibility of materials, or interactions that could discourage participation.

At the HBCU, positive DEI (Figure 2a) indicators appeared frequently across several dimensions of instruction. The most commonly observed practices included transparent communication around assignments and expectations, emphasis on help being available to all

students, and positive acknowledgment of student questions or contributions. Instructors were also observed explicitly recognizing their own limitations or errors. Such acknowledgement signals a non-hierarchical classroom dynamic. Collectively, these patterns suggest a learning environment in which instructors regularly engaged in practices that support equity, clarity, and psychological safety.

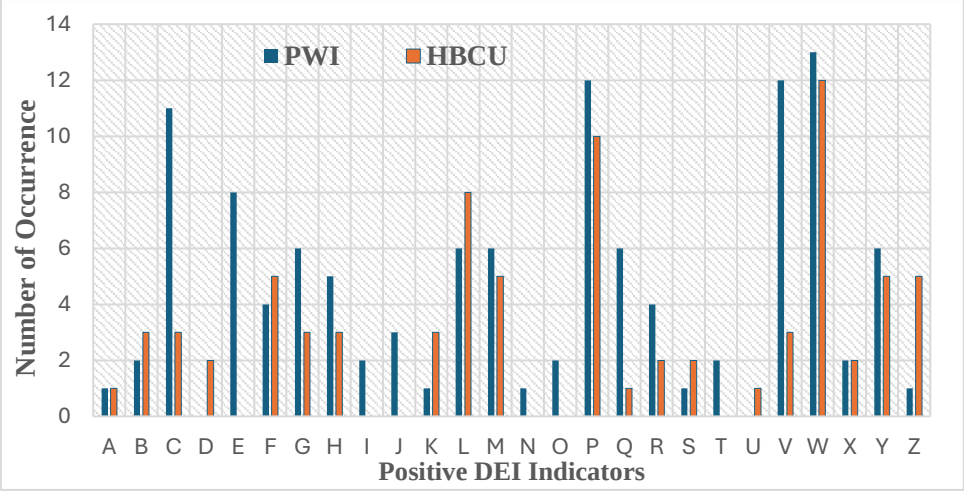
At the PWIs, positive DEI indicators were also widely observed, particularly those related to student engagement and instructional flexibility. Instructors frequently invited students to apply concepts to real-world problems, encouraged multiple possible answers, and positively acknowledged student participation. Transparent teaching practices, such as providing clear guidance on assignments and criteria for success, were among the most prominent positive indicators. These findings suggest that DEI-informed practices are embedded in many aspects of engineering instruction at PWIs, particularly those related to engagement and cognitive inclusion.

Negative DEI indicators at the HBCU (Figure 2b) were less frequent overall but still present. These included instances where cultural references were not explained, assumptions were verbalized about students or groups, or student performance trends were referenced in ways that could reinforce deficit perspectives. While these behaviors occurred at lower frequencies than positive indicators, their presence indicates that DEI integration was not uniform across all instructional moments. In the same vein, the PWIs also exhibited a higher number (Figure 2b) and wider range of negative DEI indicators compared to the HBCU. Observed challenges included accessibility issues, awkward interactions around disability accommodations, use of cold calling that placed students on the spot, and instances of put-downs or discouraging messages. Together, these findings indicate that while DEI-aligned practices are present, they coexist with instructional behaviors that may create barriers for some students.

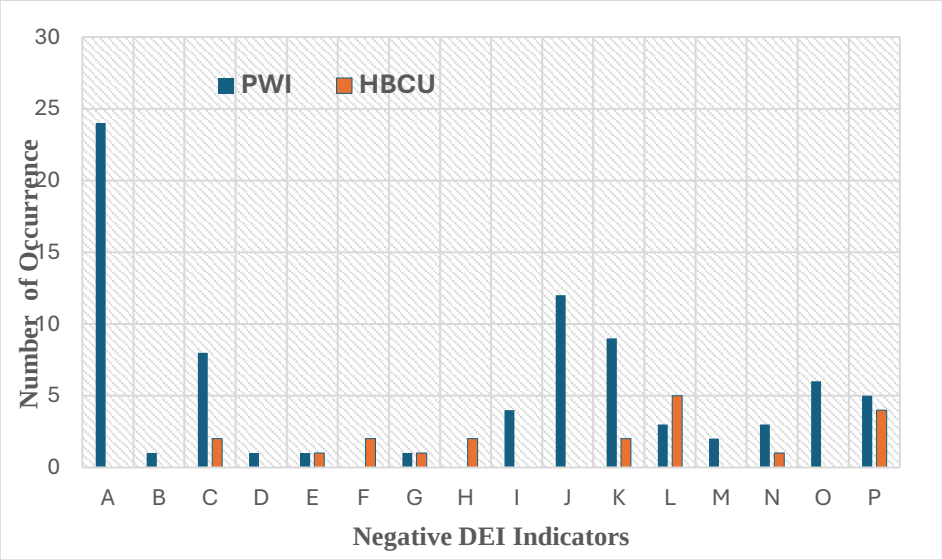
Differences in DEI-Informed Teaching Practices Across Institutional Types

Comparative analysis reveals notable differences in how DEI principles manifest in engineering lectures at the HBCU versus PWIs. At the HBCU, positive DEI indicators were concentrated around relational and supportive dimensions of teaching. Instructors frequently emphasized collective and individual academic capability, normalized help-seeking, and created space for student contributions to be acknowledged affirmatively (Figure 2a). The relatively lower number of negative indicators suggests a classroom climate that, balanced and prioritized equity-supportive interactions. In contrast, DEI-informed practices at the PWIs were characterized by strong emphasis on engagement, problem contextualization, and openness to multiple solutions. Instructors often connected course material to applications, student interests, or real-world engineering problems. Such practices reflect an inclusive approach to cognitive engagement. At the same time, PWIs exhibited substantially higher counts of negative indicators related to accessibility and classroom interactions, particularly concerning disability accommodations and assumptions about students.

These patterns suggest that while both institutional contexts demonstrate meaningful integration of DEI principles, the nature of that integration differs. The HBCU observations reflect a stronger emphasis on relational equity and instructional empathy, whereas the PWI observations show a mix of inclusive engagement practices alongside more frequent structural or interactional challenges that may undermine DEI goals.



(a)



(b)

Figure 2: Comparison of Positive and Negative DEI Indicators in PWI and HBCU

Positive DEI Keys: *Accessibility of materials (focus on ADA dimensions of accessibility);* ***B****: Allow multiple formats for assignment;* ***C****: Asks students for example of problem/situation the tool could be applied to;* ***D****: Asks students for examples of positive outcomes;* ***E****: Asks students for examples of positive outcomes;* ***F****: Build in flexibility with assignment (e.g., drop one);* ***G****: Connection to what engineering work life looks like;* ***H****: Describes a technique as a tool for building a more equitable world;* ***I****: Describes assignment/ assessment as using a student-suggested;* ***J****: Describes assignment/ assessment as using real problem;* ***K****: Emphasizes academic capability of collective, group, individual*
L*: Emphasizes help available to all who seek it;* ***M****: Explains cultural references or terms or examples that some students might not already know;* ***N****: For in-class problem, uses example from under-resourced community or population;* ***O****: Gives at least one DEI choice(s) for which problems/projects student will do****;*** ***P****: Instructor gives details about the assignment format and/or provides example(s) and/or links to course objectives, hints about how to be successful, links to the rubric (or any aspect of transparent teaching);* ***Q****: Instructor is open to disagreement from a student;* ***R****: Links a topic to a student's/s' known interest;* ***S****: Mentions career(s) as having potential to positively impact;* ***T****: Mentions positive outcomes for people from the topic (bridges, circuit boards, cell phones, etc.);* ***U****: Mentions research finding of BIPOC engineer(s);* ***V:*** *Open to more than one answer/ explanation rather than insisting on one right answer/explanation;* ***W****: Positively acknowledges a contribution or question;* ***X****: Reacts with empathy if a difficult topic comes up;* ***Y****: Statements that prof does NOT know all;* ***Z****: Statements that prof made an error.*

Negative DEI Keys: ***A****: Awkward interactions around helpers for students with disabilities (e.g., ASL interpreter or note-taker, requests for closed captioning, specific seating);* ***B****: Build in flexibility with assignment (e.g., drop one);* ***C****: Does not explain cultural references or terms or examples that some students might not already know;* ***D****: Gives at least one DEI choice(s) for which problems/projects student will do;* ***E****: Gives fixed problem sets/projects not tied to DEI;* ***F****: Ignores or disparages a contribution or question;* ***G****: Instructor gives discouraging messages such as 'this is a weed-out;* ***H****: Instructor interrupts when not necessary;* ***I****: Instructor uses cold calling, calls on individual and forces them to answer/'on the spot';* ***J****: Materials are not accessible (focus on ADA dimensions, e.g., lack of captions);* ***K****: Mentions negative outcomes for people from the content topic;* ***L****: Refers to a student or group grade/trend;* ***M****: Statements that prof knows all, students know nothing/have nothing;* ***N****: Suggests help for specific student or group (not 'if you didn't do well;* ***O****: Uses put-downs (collective, group, individual);* ***P****: Verbalizes assumptions about a student or group (success, study habits, career aspirations, preparation [not actual exam scores, see below], physical abilities).*

Statistical comparisons (Table 1) further clarify institutional differences in the distribution of DEI practices across observed engineering lectures. At the HBCU (Comparison A), positive DEI indicators were substantially more prevalent than negative indicators, with a 59.59% difference between the two, and this imbalance was statistically significant ($\chi^2 = 35.16$, p-value $= 3.03 \times 10^{-9}$). This indicates a strong predominance of equity-supportive practices in the observed lectures. A similar but less pronounced pattern was observed at the PWIs (Comparison B), where positive DEI indicators exceeded negative ones by 31.6%, and the difference remained statistically significant ($\chi^2 = 6.95$, p-value = 0.008). This suggests also a meaningful but more modest dominance of positive DEI practices. Direct comparison of positive DEI indicators across institutional types (Comparison C) revealed a smaller but statistically significant difference of 19.39% in favor of the PWI ($\chi^2 = 7.37$, $p = 0.0066$). This suggest that equity-aligned instructional behaviors were more frequently observed at the PWI than at the HBCU. In contrast, the comparison of negative DEI indicators (Comparison D) showed a pronounced and statistically significant 60% difference between institutions ($\chi^2 = 36.00$, $p = 1.97 \times 10^{-9}$), with negative practices occurring far more frequently in the PWI classrooms. Collectively, these results provide quantitative support for the qualitative patterns observed, demonstrating that while both institutional contexts exhibit DEI-informed teaching practices, the HBCU substantially fewer negative indicators than the PWI.

Tables 1: Statistical Comparison of Positive and Negative DEI Indicators at a PWI and HBCU

Comparisons	Percentage Change (%)	χ^2	p-value
HBCU Positive & Negative DEI Indicators (A)	59.59	35.16	<0.001
PWI Positive & Negative DEI Indicators (B)	31.60	6.95	0.008
PWI & HBCU Positive DEI Indicators (C)	19.39	7.27	0.007
PWI & HBCU Negative DEI Indicators (D)	60.0	36.0	<0.001

Most and Least Represented DEI Elements in Observed Lectures

Across both institutional types, certain DEI elements emerged as consistently well represented. Transparent teaching practices; such as provision of clear explanations of assignments, expectations, and pathways to success were some the most frequently observed positive indicators (Figures 2a). Similarly, positive acknowledgment of student contributions and openness to multiple answers or explanations were common across both the HBCU and PWIs. This positive acknowledgement highlights widespread attention to inclusive participation and epistemic diversity. Elements related to instructor humility, including acknowledging uncertainty or admitting errors, were also present, particularly at the HBCU and to a lesser extent at the PWIs. These practices contribute to reducing power distance in the classroom and supporting an inclusive learning environment.

In contrast, accessibility-related DEI elements were among the least consistently represented, especially at the PWIs. Negative indicators related to inaccessible materials, lack of captions, or awkward handling of disability accommodations appeared to be high in number. Additionally, practices that explicitly link engineering content to positive societal or community outcomes, especially for minoritized groups were relatively rare across both institutional contexts. These are areas where DEI integration remains limited. Finally, elements associated with flexibility and choice in assignments or assessments appeared infrequently relative to other positive indicators. Such infrequent flexibility indicates that while instructors may support inclusion through interactional practices, structural flexibility in course design is less commonly enacted.

Discussions

Findings from this study demonstrate that DEI-aligned behaviors are present in both the HBCU and PWI contexts, indicating that instructors across institutional types are engaging, to varying degrees, in inclusive teaching practices. Frequently observed behaviors, such as transparent communication of expectations, positive acknowledgment of student contributions, and openness to multiple answers suggest that many instructors are attentive to creating supportive and participatory learning environments. These practices reflect an emerging normalization of certain inclusive pedagogical approaches within engineering education [2, 22].

At the same time, the results reveal that DEI integration is uneven and often fragmented. Positive practices coexist with behaviors that may undermine equity, including unexamined assumptions about students, accessibility challenges, and discouraging or exclusionary interactions. This pattern highlights that DEI-informed teaching is not yet systematically embedded across all aspects of engineering instruction. Rather, instructors appear more comfortable enacting DEI at the level of classroom interaction than through structural or design-oriented practices, such as ensuring accessibility of materials or incorporating flexibility and choice into assessments [23].

Comparisons across institutional types further illustrate how context shapes DEI implementation. The HBCU observations suggest a stronger emphasis on relational and supportive dimensions of teaching, including empathy, normalization of help-seeking, and reinforcement of students' academic capability [4, 24, 25]. These patterns are consistent with the historic mission of HBCUs to foster affirming learning environments for students from historically marginalized backgrounds [6, 26]. In contrast, the PWI exhibited robust engagement-focused practices, such as encouraging multiple solutions and connecting course content to real-world applications. Lecture in the PWI also displayed a higher number of negative DEI indicators, particularly related to accessibility and classroom dynamics. This juxtaposition underscores that inclusive intent does not automatically translate into inclusive outcomes, especially when structural supports are insufficient [11, 27].

Across both contexts, certain DEI elements were more consistently represented than others. Practices related to instructional clarity and student participation were widespread, likely because they align closely with broader conceptions of effective teaching [2, 10, 28]. In contrast, accessibility-related practices and explicit connections between engineering content and societal or community impact were comparatively rare. These gaps suggest that some dimensions of DEI, especially those requiring systemic awareness or redesign of instructional materials remain underdeveloped within engineering classrooms [11].

Learnings form these finding emphasizes that DEI integration in engineering education should be understood as a continuum rather than a binary condition. While meaningful progress is evident, particularly in interactional and engagement-oriented practices, persistent gaps point to the need for more comprehensive approaches that address both interpersonal and structural dimensions of inclusion. By documenting real classroom practices across institutional contexts, this study contributes to a more nuanced understanding of how DEI is currently enacted in engineering education and where future efforts may be most productively directed.

These findings suggest that transforming engineering education communities requires moving beyond surface-level inclusion toward pedagogies that critically interrogate power, access, and historical exclusion embedded within technical training. Grounding DEI work in liberatory struggles against empire calls for re-examining how engineering knowledge is framed, whose experiences are legitimized, and how curricula either reproduce or challenge dominant socio-technical hierarchies. Such transformation entails shifting from fragmented inclusive practices

to structurally conscious, justice-oriented educational communities that position engineering as accountable to historically marginalized peoples and global equity concerns.

Conclusion and Future Work

This study examined the extent to which DEI principles are integrated into engineering teaching practices by systematically analyzing observed classroom behaviors at selected PWI and an HBCU. Findings from this study document the presence of DEI-aligned instructional practices across both institutional contexts. Meaningful variations in how these practices are enacted were also revealed. By focusing on real classroom interactions rather than institutional statements or self-reports, the study provides empirical evidence of how DEI is operationalized in everyday engineering instruction.

The results show that instructors at both PWIs and the HBCU incorporate several DEI-informed practices, particularly those related to instructional transparency, student engagement, and acknowledgment of student contributions. However, differences emerged across institutional types, with the HBCU demonstrating a stronger emphasis on relational and supportive teaching practices, and PWIs exhibiting greater variability, including higher frequencies of both positive engagement-oriented behaviors and negative indicators related to accessibility and classroom interactions. These findings highlight that DEI integration is not uniform and is shaped by institutional context, instructional norms, and structural supports.

Analysis of individual DEI elements further revealed that while interactional forms of inclusion are relatively well represented, structural dimensions, such as accessibility of materials, flexibility in course design, and explicit connections between engineering content and societal or community impact remain underrepresented. This imbalance suggests that current DEI efforts in engineering education may prioritize interpersonal inclusivity over systemic or design-oriented approaches. This imbalance leaves important equity gaps unaddressed.

Future research should expand this work by examining a broader range of institutions and engineering disciplines. Such studies should also incorporate longitudinal designs to assess changes in DEI practices over time. Additionally, linking classroom-level DEI indicators to student outcomes would provide further insight into the effectiveness of specific practices. Collectively, such efforts can support the development of evidence-based strategies that move DEI in engineering education beyond intent and rhetoric toward sustained, measurable pedagogical transformation.

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