2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #50964

Barriers within Design: Understanding Disabled Students' Experiences in Undergraduate Engineering Programs through a Universal Design for Learning Lens

Mr. Chima Frankfreds Umeaku, University of Georgia

Chima Umeaku is a Ph.D. student in Engineering Education at the University of Georgia. His research explores pedagogical approaches and alternative learning pathways in engineering education, focusing on how instructional design and sociotechnical environments shape access, participation, and learning across formal and informal contexts.

Dr. Rachel Figard, University of Georgia

Dr. Rachel Figard is an Assistant Professor at the University of Georgia in the Engineering Education Transformations Institute (EETI) and the Department of Environmental, Civil, Agricultural, and Mechanical Engineering (ECAM). Her primary areas of research include disabled student experiences, design justice, the impact of institutional policy and practice on student experience, and accessible user experience design. She received a Ph.D. in Engineering Education Systems and Design from Arizona State University (ASU), an M.S. in User Experience from ASU, and a B.S. in Industrial Engineering from North Carolina State University.

Barriers within Design: Understanding Disabled Students' Experiences in Undergraduate Engineering Programs through a Universal Design for Learning Lens

Abstract

This full, empirical research paper presents a scoping literature review (ScLR) of scholarship examining disabled students' lived experiences in undergraduate engineering programs. The study investigates how the Universal Design for Learning (UDL) 3.0 framework can inform more inclusive pedagogical practices in engineering learning environments. Although disability has received increasing attention within engineering education research, the literature remains fragmented and underutilized as a source for driving instructional change. In particular, limited work has examined how strategies aligned with UDL appear in, or are absent from, studies that center disabled students' experiences.

Six databases were searched for peer-reviewed journal articles and conference papers published between 2009 and 2025. The search employed comprehensive disability identity terminologies and applied four central inclusive criteria: disabled students, undergraduate engineering, lived experiences, and U.S. higher institutions. The search yielded 6,388 records, with 41 studies meeting all criteria after duplicate removal and three rounds of screening. The UDL framework served as the analytical lens for data charting and interpretation.

This paper documents persistent structural and cultural barriers for disabled students in engineering, including rigid accommodation processes, stigma surrounding disclosure, and inflexible instructional practices that undermine disabled students' engagement and persistence in engineering. At the same time, several studies describe practices aligned with UDL, such as multimodal content delivery, flexible assessment timelines, proactive instructor communication, and supportive peer and faculty relationships. Additional themes, including social capital and transition strain, extend beyond the framework and point to broader institutional forces shaping disabled students' experiences. The paper highlights both the limited integration of disability-centered practices in engineering education and opportunities for reform.

Keywords: *Disability, disabled students, student experience, undergraduate, learning environment, Universal Design for Learning (UDL), literature review*

Introduction and Background

Disabled students in undergraduate engineering programs encounter systemic barriers that shape their academic engagement, sense of belonging, and persistence [1]. These barriers are experienced in many (often confounding) ways, including through inaccessible physical environments, stigmatizing norms around disability disclosure, complex and reactive accommodation processes, and cultural expectations that valorize perceived toughness and individualism [2], [3]. Prior literature describes how engineering culture often frames disability through deficit-oriented lenses by positioning access needs as "deviations" from a presumed norm [1]. Such framings contribute to the larger systemic silencing of disabled students' needs and reinforce exclusion from the discipline.

Notably, these conditions often shift the burden of access onto disabled students, who must navigate engineering programs through disclosure decisions, self-advocacy, and reliance on informal support networks [4], [5]. These patterns do not reflect "exceptional" perseverance or resilience, but rather a systemic misalignment between engineering learning environments and disability [1]. Scholarship examining these lived experiences, however, remains fragmented, limiting the field's ability to translate this body of work into cumulative knowledge that can inform inclusive engineering education practice.

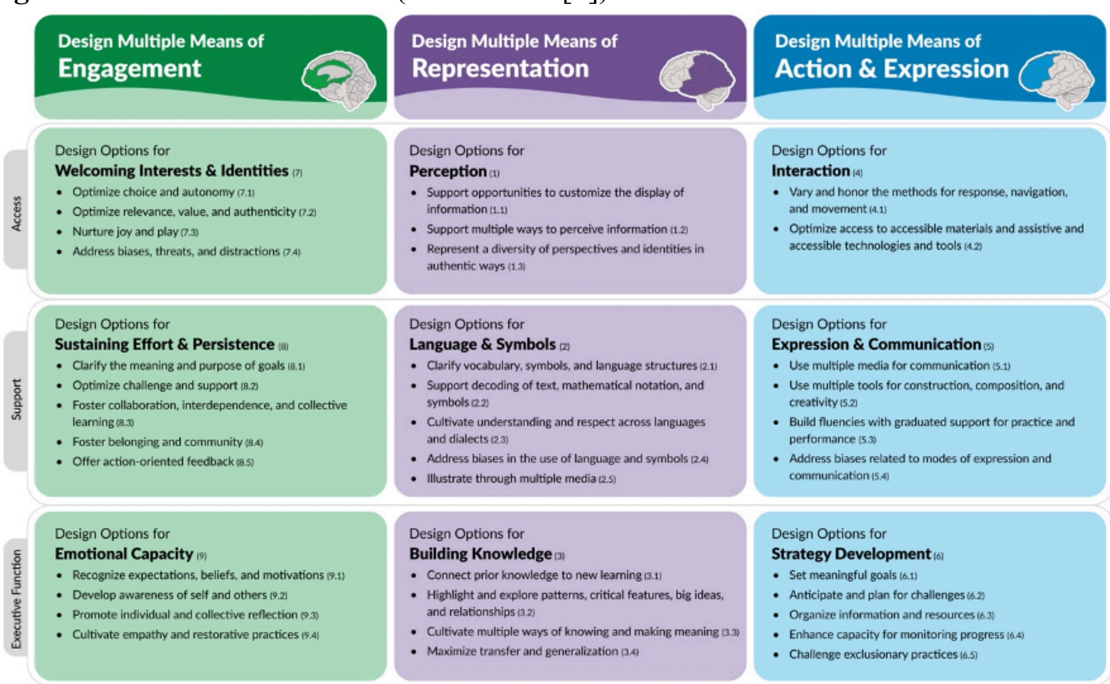
The Universal Design for Learning (UDL) 3.0 framework offers a promising conceptual foundation for this work [6]. The framework highlights strategies that leverage multiple means of engagement, representation, and action/expression in promoting intentional learning design that values diversity among students [6]. Understanding disabled students' experiences through the lens of UDL provides a structured approach for (1) synthesizing prior research and (2) interpreting engineering education's potential alignments and misalignments with accessibility and anti-ableism.

Accordingly, this paper reports findings from a scoping literature review (ScLR) of literature related to disabled students' lived experiences in undergraduate engineering. This study addresses the following research questions (RQs):

> ***RQ1:*** *What is the current landscape of literature around disabled student experiences in undergraduate engineering programs?*
>
> ***RQ2:*** *How may UDL-based strategies help in addressing disabled students' challenges in undergraduate engineering programs?*

Universal Design for Learning (UDL) as a Guiding Conceptual Framework

Figure 1: *UDL Framework 3.0* (Taken from [6])



UDL is an educational framework developed by CAST to support the design of accessible and inclusive learning environments for all learners [6]. The UDL Guidelines 3.0 articulate three core principles: multiple means of engagement (recognizing variability in learners' identities and motivations); multiple means of representation (acknowledging that individuals perceive and process information in diverse ways); and multiple means of action and expression (emphasizing the need for flexible options for learners to demonstrate what they know). Collectively, these principles can help guide educators and institutions in proactively designing curricula that anticipate and accommodate learner diversity [6]. In practice, UDL promotes flexibility in how students access, participate in, and demonstrate learning, ultimately supporting improved engagement and learning outcomes. **Figure 1** details the full UDL 3.0 framework, including its accompanying guidelines and recommendations.

The UDL Framework 3.0 [6] functions as a guiding interpretive framework for examining how disabled undergraduate engineering students' experiences align with (or diverge from) the values and design commitments embedded within UDL. By foregrounding learner variability and the need for proactive design, the framework helps reveal both the affordances and shortcomings of current engineering learning environments. This framework, therefore, illuminates opportunities for more inclusive pedagogical approaches that intentionally address barriers to participation, belonging, and equitable learning outcomes for disabled students.

Author Positionalities

The first author approaches this work as a scholar committed to equity and belonging in engineering learning environments. His research aims to improve disability inclusion in engineering pedagogies, shaped by prior experiences supporting diverse undergraduate students. The second author engages with this work through her identities as a disabled woman, tenure-track faculty member, and engineering education researcher. She comes to this research with a nuanced understanding of the disabled student experience and navigational barriers in the engineering education ecosystem.

Methods

Methodological Overview

This study reports findings from a completed scoping literature review examining disabled students' lived experiences in undergraduate engineering programs in the United States. The methodological details of the ScLR were published by [7], who detailed the protocol, search strategy, and preliminary screening results. The present paper extends that work in three key ways. First, it reports the updated search query criteria. Second, it presents findings from the completed full-text screening and data charting phases, analyzed through the lens of the UDL 3.0 framework. Third, it examines how principles of UDL may align with the experiences (e.g., barriers, positive experiences, helpful tools) reported by disabled students in engineering across the included studies.

Scoping Literature Review (ScLR) Protocol

ScLRs are conducted to map the research landscape within a specific content area, providing an overview of existing literature and identifying gaps for future inquiry. This method differs from systematic literature reviews in its flexibility and broader research focus, as ScLR aims to synthesize and summarize literature without the rigid formalized structure of systematic reviews [8], [9], [10]. ScLRs are particularly effective for quickly identifying key concepts, evidence, and trends relevant to a defined research question [10], [11].

This ScLR follows the methodology presented by [10], which breaks the process into five stages: (1) identifying the research questions, (2) identifying the relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results. These stages were performed iteratively to allow for researcher reflection along each stage.

Stage 1: Identify Research Questions

The present paper is guided by two research questions, which are built directly from a previously published work-in-progress ScLR [7]:

RQ 1: *What is the current landscape of literature around disabled student experiences in undergraduate engineering programs?*
RQ 2: *How may UDL-based strategies help in addressing and supporting disabled students in undergraduate engineering programs?*

Stage 2: Identify Relevant Studies

The ScLR was anchored in four central inclusion criteria that operationalize our focus on disabled students' lived experiences in undergraduate engineering:

1. Disabled student: The literature must include students who identify as disabled as a primary study population, including those with physical disabilities, neurodivergence (e.g., ADHD, Autism), chronic illnesses, sensory disabilities (e.g., Deaf/hard of hearing or blind/visually impaired), non-apparent disabilities, and apparent disabilities.
2. Engineering education: The studies must be situated in undergraduate engineering education, including but not limited to in-classroom experience, socialization, or curricular, pedagogical, or institutional practices.
3. Lived experience: The research must center disabled students' articulated experiences, accounts, or perspectives (e.g., expressed barriers, supports, strategies for navigating engineering).
4. Undergraduate education: The setting must be four-year undergraduate institutions/programs in the U.S.

Additional criteria bounding the identification and inclusion of studies are more comprehensively detailed in [7]. In summary, publications had to be (1) peer-reviewed journal articles or conference papers, (2) written in English, (3) published between January 1, 2009, and January 1, 2025, and (4) focus on U.S. bachelor's degree-granting institutions.

These criteria guided our search for existing literature in the following online databases: Engineering Village (Compendex, Inspec), ProQuest (ERIC, Education Database), EBSCOHost, Scopus, ASEE PEER, and IEEE Xplore. A generalized search query was created (**Figure 2**) for the databases to ensure consistency in the searches across databases. This search query intentionally incorporated both identity-first and person-first phrases (e.g., "Autism," "Autistic") to broaden the scope of the search and to later examine patterns in language use across the literature.

Databases were searched individually, and results were exported into a Google Sheets spreadsheet to prepare for study selection. To capture the evolving literature and ensure coverage across the specified publication window, the database search was conducted twice, first in September 2024 and again in January 2025, resulting in 6,388 publications. After removing duplicates, 5,794 unique publications remained for study selection and analysis.

Figure 2: *Search Query Criteria*

"Disabled" OR "disability" OR "disabilities" OR "neurodivers[e, ity]" OR "neurodivergent" OR "SWD" OR "PWD" OR "ADHD" OR "Autis[m, tic]", OR "Deaf" OR "Deaf/Hard of Hearing" OR "Deaf/Hard-of-Hearing" OR "DHH" OR "Blind" OR "Blind/Low Vision" OR "Blind-or-Low-Vision" "BLV" OR "Chronic Illness" OR "Chronically Ill" OR "Mental Health" OR "MH" OR "Mental Health and Wellbeing" OR "MHW" OR "Impaired"
AND
"engineering education" OR "engineering" OR ("engineering" AND "education") OR "computer science education" OR "CS education" OR (("engineering" OR "computer science" OR "cs") AND "education") OR "STEM education" OR ("STEM" AND "education") OR "STEM" OR "computing education" OR ("computing" AND "education") OR "agricultural engineering" OR "biological engineering" OR "biomedical engineering" OR

"BME" OR "chemical engineering" OR "ChemE" OR "computer engineering" OR "computer science" OR "CS" OR "computing" OR "civil engineering" OR "electrical engineering" OR "electrical and computer engineering" OR "ECE" OR "environmental engineering" OR "human systems engineering" OR "HSE" OR "industrial engineering" OR "IE" OR "manufacturing engineering" OR "material engineering" OR "mechanical engineering" OR "MechE" OR "mining engineering" OR "nuclear engineering" OR "petroleum engineering" OR "software engineering" OR "systems engineering" OR "textile engineering"
AND
"Lived experience" OR "experience" OR "barriers" OR "challenges" OR "support" OR "support strategies" OR "accessibility" OR "access" OR "ableism" OR "ableist" OR "anti-ableist" OR "accommodations"
AND
"college" OR "university" OR "post-secondary" OR "postsecondary" OR "post secondary" OR "higher education" OR "undergraduate" OR "undergrad"

Stage 3: Study Selection

A three-round screening cycle was then employed to select the studies: (1) title screening, (2) abstract screening, and (3) full-text screening. A screening tool was created to standardize study selection using the inclusion and exclusion criteria. During the review, papers were noted if the study would be included in the next screening cycle and, if not, the reasons why (defined by the inclusion criteria that were not met).

Initially, papers were assessed based on relevance to the research question using predefined inclusion and exclusion criteria. To ensure reliability, the screening process was conducted collaboratively by multiple researchers. During screening stages, each paper was independently reviewed by two members of the research team. In cases of disagreement, a third member reviewed the study, and final decisions were made by consensus. The full-text analysis was conducted by an additional researcher who was not involved in the study screening process. 41 papers remained after completing the three screening cycles. **Appendix A** further details the screening process for our study.

Stage 4: Charting the Data

UDL 3.0 [6] served as an analytical lens for examining the reported experiences of disabled undergraduate engineering students in academic literature. During the charting phase, reported findings from each included study were mapped to the framework's principles. For example, reports of non-disclosure of disability status or rigid accommodation processes were associated with the principle "Action and Expression", while experiences related to belonging and classroom climate were mapped to "Engagement." Experiences related to curriculum design and course content presentation were categorized under "Representation." Data that did not align with any principle were coded separately to preserve nuance and detail.

Findings

Across the 41 studies, disabled students' experiences in undergraduate engineering reflected persistent patterns related to Engagement, Representation, and Action and Expression. **Tables 1** through **3** summarize how these experiences mapped onto the Universal Design for Learning framework. Together, the studies reveal both enduring barriers to access and examples of instructional practices that supported disabled students' participation and persistence.

Engagement

Findings related to Engagement (**Table 1**) emphasize that disabled students' motivation, persistence, and sense of belonging were often shaped by instructional practices and institutional cultures, rather than by individual effort or ability alone [1], [12], [13]. Across the literature, students' engagement was closely tied to whether learning environments recognized and valued their identities [2], [14], supported sustained effort through accessible and flexible structures [15], [16], and acknowledged emotional well-being as integral to their participation [17], [18]. Many studies documented how engineering's cultures of excessive rigor and competition [2], [13], and structural barriers like laboratory and classroom access and arrangements [19], [27] challenge disabled students' participation in learning. These challenges, along with stigmatizing attitudes from faculty and peers [19], [20] and unclear disability accommodations processes [5], [21], [38], often require students to weigh decisions about disability disclosure against potential risks to their social and professional standing [13]. In this context, engagement becomes contingent on the student's ability to overcome systemic barriers rather than arising from their intrinsic motivation.

In contrast, supportive relationships with instructors and peers [4], [14], [22], along with flexible and transparent policies [23] and affirming classroom climates, were associated with increased persistence and participation [4], [22], [24]. Environments that recognized learners' intersecting identities, including race/ethnicity, culture, gender, language, and disability, were more likely to promote sustained engagement by validating students' experiences and contributions [14]. Similarly, accommodation processes that minimized administrative burden and avoided singling out students in the classroom (e.g., built-in flexibility or extensions policies) helped reduce feelings of othering and supported equitable participation [20], [23], [25], [26]. Collectively, these findings suggest that engagement in engineering is not simply enabled through inclusion but is fundamentally shaped by how the learning environments distribute access, recognition, and support.

Table 1: *Mapping of UDL Engagement Guidelines to Disabled Students' Experiences*

Engagement Guidelines	Description	Articles Included
Welcoming Interests & Identities	How learning environments acknowledge and value the identities, motivations, and lived experiences students bring into engineering spaces. Articles discussed how instructor attitudes, peer interactions, and accommodation processes shaped students' sense of belonging and motivation.	[1], [2], [12–14], [20], [22], [23], [25], [27–30]
Sustaining Effort & Persistence	Instructional structures and cultural norms influence students' motivation over time. Studies highlighted how program rigor, workload expectations, and access to support either supported or discouraged disabled students' persistence in engineering.	[2–5], [12], [13], [15], [16], [23], [24], [31–37]
Emotional Capacity	The emotional dimensions of learning include stress, anxiety, confidence, and belonging. Papers examined how emotional experiences shaped engagement and how classroom climates and institutional practices contributed to or alleviated affective strain.	[13], [17], [18], [20], [23], [31], [38–40]

Representation

Findings mapped to Representation (**Table 2**) highlight the central role of instructional design in shaping disabled students' access to engineering content. Across the literature, representation extends beyond how information is delivered to include how learners perceive, interpret, and make meaning of that information within the constraints of engineering curricula. This process of knowledge interpretation and integration is shaped by learners' sensory, cognitive, cultural, and linguistic capacities [6]. Students described how reliance on singular modes of content delivery, such as text-heavy or lecture-based formats, negatively impacted comprehension and increased cognitive load, particularly in fast-paced or highly technical courses [31]. When instruction depended on inflexible formats, students' access and engagement decreased because they had to adjust to the way course material was presented, rather than having options that fit their needs [23], [31].

In contrast, multimodal approaches (such as recorded lectures, accessible documents, tactile and verbal descriptions, and flexible access to materials) supported learning and engagement across a range of sensory, cognitive, and contextual needs [41]. These approaches enabled students to engage with learning content through preferred or complementary modalities. For example, students reported valuing access to recorded lectures and printable materials, as well as formats such as tactile Braille component cards, verbal descriptions of visuals, consistent alt-text, and embodied strategies like "hand-drawing" circuits on their palms [31], [35]. Materials that were searchable and downloadable (e.g., recorded audio/video with transcripts or graphics) further enhanced content clarity and accessibility for learners [20], [41].

Together, these findings demonstrate that representation in engineering is not neutral, and reflects assumptions about how knowledge should be communicated within the discipline. Reliance on singular modes of representation creates barriers to access, while intentional diversification of formats supports more equitable and sustained engagement with engineering content.

Table 2: *Mapping of UDL Representation Guidelines to Disabled Students' Experiences*

Representation Guidelines	**Description**	**Articles Included**
Perception	How course content is made perceptible through different sensory and cognitive modalities. The articles discussed the multiple ways and formats in which course contents are presented and the effects on learning for the students.	[2–4], [23], [31], [32], [42]
Language & Symbols	Clarity and accessibility in how information is communicated. Papers focused on the use of language, visuals, notation, and symbolic representations, and how these choices shaped meaning-making and comprehension for students.	[2], [31], [35], [38], [41]
Building Knowledge	How instructional design supports the development of understanding by connecting new material to prior knowledge. The literature highlighted scaffolding strategies that supported conceptual learning and reduced barriers to engaging with complex engineering content.	[31]

Action & Expression

Findings related to Action and Expression (**Table 3**) illustrate how disabled students' participation in engineering learning environments is often shaped by the availability of flexible pathways for interaction and assessment. Across the literature, practices such as clear expectations, timely and constructive feedback, multiple communication channels (e.g., online office hours, chat-based Q&A, written resources), and varied ways of demonstrating learning supported students' engagement and agency [12], [23]. These approaches allowed students to demonstrate understanding in ways that aligned with their strengths. In contrast, rigid evaluation structures, high-stakes assessments, and narrow participation expectations intensified barriers, often requiring students to expend additional effort to translate their knowledge into accepted formats [14], [25].

Inclusive learning environments were characterized by instructional and relational practices that normalized flexibility, fostered psychological safety, and enabled students to communicate needs without stigma. Examples included through mentorship programs, flexible assignments, respectful and affirming language, and transparent expectations [12], [19], [23], [27]. Embedding flexibility into the course design reduced reliance on self-advocacy as a primary mechanism for access.

At the same time, many studies detailed how anxiety surrounding disclosure and reliance on formal accommodation systems often limited students' willingness or ability to access available support [4], [43]. This dynamic reinforces inequities by making access contingent on students' willingness to disclose rather than on the design of the learning environment. Increasing the visibility and accessibility of accommodations is therefore critical to ensuring that students can make use of available supports [3], [43].

Overall, these findings suggest that action and expression in engineering are shaped by how participation is structured and supported. When flexibility is intentionally embedded within instructional design, it enables more equitable and authentic demonstration of learning.

Table 3: *Mapping of UDL Action and Expression Guidelines to Disabled Students' Experiences*

Action & Expression Guidelines	**Description**	**Articles Included**
Interaction	How learners interact with instructors, peers, tools, and learning environments. Studies examined how technologies, classroom practices, and institutional behaviors either supported or constrained disabled students' participation.	[3], [4], [12], [23], [31], [39], [43–45]
Expression & Communication	The ways learners are able to communicate understanding and engage academically. The literature highlighted the role of multiple communication channels and flexible participation formats in supporting disabled students' agency and access.	[12], [13], [21], [23], [31], [41], [42], [44]
Strategy Development	Supports that help learners develop executive functioning strategies (e.g., organizing, problem solving, and adapting within learning environments). Studies examined instructional and relational practices that supported disabled students' navigation of academic tasks.	[12], [14], [19], [23], [25], [27], [31], [44]

Themes Extending Beyond the Instructional Scope of the UDL Framework

Some findings in the literature extended beyond the instructional scope of the UDL framework (detailed in **Table 4**). Taken together, these themes highlight the limits of UDL as a standalone lens for understanding disabled students' experiences in engineering, as they point to structural, institutional, and relational conditions that shape access and participation.

Specifically, the literature identities barriers embedded in physical environments, institutional attitudes, and policy structures that affect access to facilities, equipment, and learning spaces [19]. It also highlights the role of social networks and informal support systems in shaping students' access to resources, information, and a sense of belonging within engineering programs [46]. Additionally, studies document transitional pressures associated with entering engineering, including cultural adjustment and the need to translate prior experiences and skills into new disciplinary contexts [3].

Table 4: *Themes Extending Beyond the Instructional Scope of the UDL Framework*

Themes	**Description**	**Articles Included**
Physical & Attitudinal Barriers	Structural and cultural conditions, such as inaccessible facilities, laboratory equipment, and institutional attitudes toward disability, that shape students' participation. These factors influence access to learning environments at a systems level and constrain the extent to which instructional design strategies alone can mitigate barriers.	[19]
Social Capital	Informal networks, relationships, and support systems that shape students' access to resources, information, and opportunities. The literature highlights how these relational dynamics support belonging and navigation within engineering programs, operating alongside formal instruction rather than within pedagogical design itself.	[16], [46]
Transition Strain	Pressures associated with entering engineering programs, including cultural adjustment and the translation of prior skills and identities into new disciplinary contexts. These experiences shape students' early engagement and persistence trajectories and unfold across institutional and social contexts.	[3]

Discussion, Implications, and Future Work

Our findings demonstrate how disabled students' experiences in undergraduate engineering are shaped by the interaction of instructional practices, cultural norms, and structural conditions. Across the literature, barriers to access and participation were not limited to individual courses or instructors, but reflected broader cultural conditions that influence expectations for learning, performance, and participation in engineering. Applying the UDL 3.0 framework provides a useful lens for examining how these experiences align with, or diverge from, accessibility-oriented instructional design.

The literature further highlights how institutional bureaucratization of accommodations and persistent ableist assumptions within engineering culture continue to shape disabled students' engagement and persistence [39], [43]. Although some instructional practices aligned with UDL principles, such as multimodal content delivery and flexible assessment timelines, these practices were unevenly implemented and often constrained by broader structural conditions. For example, although recorded lectures and tactile resources supported access, many instructional materials remained inaccessible by default [31]. Recent federal regulations now require public universities to ensure that digital course content meets Web Content Accessibility Guidelines (WCAG) 2.1 Level AA standards by 2026 [48], [49]. While these requirements establish a baseline for accessibility, they do not address how complex engineering content is designed, represented, and assessed in accessible ways.

Similarly, although proactive feedback and deadline flexibility supported engagement for some, rigid disclosure requirements and accommodation processes shifted responsibility for access onto students and discouraged use of available support [13]. Embedding accessibility within instructional design through UDL offers a pathway toward more inclusive learning environments, but its impact depends on institutional commitment and cultural change. Faculty development is critical in this effort, as instructors' pedagogical choices, communication practices, and underlying assumptions about learners directly shape participation and belonging [5], [20], [22]. At the same time, disability inclusion must be situated within intersectional frameworks that recognize how ableism interacts with other forms of marginalization, shaping students' experiences in complex and compounding ways [22], [39].

Future research should examine how UDL-based interventions influence disabled students' engagement, persistence, and sense of belonging in engineering, particularly across varied institutional contexts. Longitudinal studies could further illuminate how disclosure practices and access strategies evolve over time. Additionally, future work should extend beyond classroom instruction to examine how engineering-specific infrastructures, such as laboratories, design spaces, and technical tools, along with advising and transition supports, shape disabled students' access and participation.

Limitations

The scope of included studies was bounded by database access and publication availability, and some potentially relevant work may not have been included due to a lack of full-text access or because it addressed broader higher education areas not specific to engineering contexts. As a result, this review may not capture the full breadth of disability-related experiences across all engineering programs. In addition, the study focused exclusively on U.S.-based undergraduate engineering education and included literature published between 2009 and January 2025, which limits the representation of earlier scholarship, international perspectives, and research published after the search window. Finally, while the UDL framework provided a useful lens for organizing and synthesizing findings, overlap across guidelines occasionally complicated analytic distinctions, and several themes, particularly those extending beyond classroom instruction, fell outside the framework's primary scope.

Concluding Thoughts

This review synthesized findings from 41 studies examining disabled students' lived experiences in undergraduate engineering programs through the lens of the UDL 3.0 framework. The findings show that disabled students encounter persistent barriers across Engagement, Representation, and Action and Expression. While some instructional practices supported access and participation, responsibility for navigating these environments often remained with students, which required sustained self-advocacy and knowledge of institutional systems.

Applying the UDL framework illuminated both areas of alignment and gaps in how engineering learning environments support accessibility. At the same time, themes extending beyond the framework highlight that barriers are also produced through institutional structures, physical environments, and social networks that shape participation across the broader educational context. Together, these findings suggest that advancing accessibility in engineering requires not only integrating accessibility into instructional design, but also addressing the structural and cultural conditions that distribute access.

References

[1] E. A. Cech, "Engineering ableism: The exclusion and devaluation of engineering students and professionals with physical disabilities and chronic and mental illness," *J. Eng. Educ.*, vol. 112, no. 2, pp. 462–487, Apr. 2023, doi: 10.1002/jee.20522.

[2] K. Robert and J. Leydens, "Dignity and well-being: Narratives of modifying the culture of engineering education to improve mental health among underrepresented STEM students," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 43178. doi: 10.18260/1-2--43178.

[3] M. Sheppard, N. Kellam, and S. Brunhaver, "Exploring the Unique Skills and Challenges that Veterans with Disabilities Bring to College: A Qualitative Study in Engineering," in *2019 CoNECD - The Collaborative Network for Engineering and Computing Diversity Proceedings*, Crystal City, Virginia: ASEE Conferences, Apr. 2019, p. 31763. doi: 10.18260/1-2--31763.

[4] M. A. Pfeifer, E. M. Reiter, J. J. Cordero, and J. D. Stanton, "Inside and Out: Factors That Support and Hinder the Self-Advocacy of Undergraduates with ADHD and/or Specific Learning Disabilities in STEM," *CBE—Life Sci. Educ.*, vol. 20, no. 2, p. ar17, Jun. 2021, doi: 10.1187/cbe.20-06-0107.

[5] R. Figard, S. Brunhaver, and J. Bekki, "'It is So Exhausting to Constantly Have to Explain to People': Exploring the Effects of Faculty Interactions on Disabled Students," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 42321. doi: 10.18260/1-2--42321.

[6] CAST, "CAST Universal Design for Learning Guidelines version 3.0." [Online]. Available: https://udlguidelines.cast.org/

[7] Anonymized for Review.

[8] M. Borrego, M. J. Foster, and J. E. Froyd, "Systematic Literature Reviews in Engineering Education and Other Developing Interdisciplinary Fields," *J. Eng. Educ.*, vol. 103, no. 1, pp. 45–76, Jan. 2014, doi: 10.1002/jee.20038.

[9] M. J. Grant and A. Booth, "A typology of reviews: an analysis of 14 review types and associated methodologies," *Health Inf. Libr. J.*, vol. 26, no. 2, pp. 91–108, Jun. 2009, doi: 10.1111/j.1471-1842.2009.00848.x.

[10] H. Arksey and L. O'Malley, "Scoping studies: towards a methodological framework," *Int. J. Soc. Res. Methodol.*, vol. 8, no. 1, pp. 19–32, Feb. 2005, doi: 10.1080/1364557032000119616.

[11] S. S. Samnani, M. Vaska, S. Ahmed, and T. C. Turin, "Review Typology: The Basic Types of Reviews for Synthesizing Evidence for the Purpose of Knowledge Translation".

[12] R. A. Figard and A. R. Carberry, "A Law of Diminishing Returns: Quantifying Online Accessibility for Engineering Students With Disabilities in the Wake of the COVID-19 Pandemic," *IEEE Trans. Educ.*, vol. 67, no. 3, pp. 434–442, Jun. 2024, doi: 10.1109/TE.2023.3326760.

[13] C. McCall, M. Paretti, L. McNair, A. Shew, D. Simmons, and C. Zongrone, "Leaving Civil Engineering: Examining the Intersections of Gender, Disability, and Professional Identity," in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual On line: ASEE Conferences, Jun. 2020, p. 34906. doi: 10.18260/1-2--34906.

[14] H. Hartman *et al.*, “Strategies for Improving Diversity and Inclusion in an Engineering Department,” *J. Prof. Issues Eng. Educ. Pract.*, vol. 145, no. 2, p. 04018016, Apr. 2019, doi: 10.1061/(ASCE)EI.1943-5541.0000404.
[15] E. da Silva Cardoso, B. Phillips, K. Thompson, D. Ruiz, T. Tansey, F. Chan, “Experiences of Minority College Students with Disabilities in STEM,” *Journal of Postsecondary Education and Disability, 29(4), 375-388 375.*
[16] J. Whitney, S. Langley-Turnbaugh, L. Lovewell, and B. Moeller, “Building Relationships, Sharing Resources, and Opening Opportunities: A STEM Learning Community Builds Social Capital for Students with Disabilities,” *Journal of Postsecondary Education and Disability, vol. 25, no. 2, pp. 131–144*.
[17] K. Beddoes and A. Danowitz, “Learning from Universities’ Responses to the COVID-19 Pandemic: Lessons for the New Normal,” *European Society for Engineering Education Annual Conference 2021*, Sep. 2021.
[18] G. K. Saw, C.-N. Chang, S. Lin, P. R. Hernandez, and R. Culbertson, “Disparities in mentoring and mental health problems of U.S. college students in science and engineering during the COVID-19 pandemic,” *Educ. Psychol.*, vol. 43, no. 5, pp. 509–530, May 2023, doi: 10.1080/01443410.2022.2146055.
[19] H. Jeannis, M. Goldberg, K. Seelman, M. Schmeler, and R. A. Cooper, “Barriers and facilitators to students with physical disabilities’ participation in academic laboratory spaces,” *Disabil. Rehabil. Assist. Technol.*, vol. 15, no. 2, pp. 225–237, Feb. 2020, doi: 10.1080/17483107.2018.1559889.
[20] C. Groen-McCall, L. McNair, M. Paretti, A. Shew, and D. Simmons, “Board 102: Exploring Professional Identity Formation in Undergraduate Civil Engineering Students Who Experience Disabilities: Establishing Definitions of Self,” in *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida: ASEE Conferences, Jun. 2019, p. 32170. doi: 10.18260/1-2--32170.
[21] C. Zongrone, C. McCall, M. Paretti, A. Shew, D. Simmons, and L. McNair, “‘I’m Looking at You, You’re a Perfectly Good Person …’: Describing Non-Apparent Disability in Engineering,” in *2021 CoNECD Proceedings*, Virtual - 1pm to 5pm Eastern Time Each Day: ASEE Conferences, Jan. 2021, p. 36059. doi: 10.18260/1-2--36059.
[22] C. McCall, A. Shew, M. Paretti, D. Simmons, and L. McNair, “Redefining and Reconceptualizing Disability Identity in Civil Engineering,” in *2022 ASEE Annual Conference & Exposition Proceedings*, Minneapolis, MN: ASEE Conferences, Aug. 2022, p. 42078. doi: 10.18260/1-2--42078.
[23] H. Ji, I. Han, and S. Park, “Teaching foreign language with conversational AI: Teacher-student-AI interaction,” *Language learning & Technology*, vol. 28, no. 2, p. 91-108, Jun. 2024, doi: 10.64152/10125/73573.
[24] I. Miller and K. Jensen, “Board 116: Experiences of Engineering Students with Disabilities,” in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 46672. doi: 10.18260/1-2--46672.
[25] S. Lezotte, H. Hartman, S. Farrell, and T. Forin, “Disability and Engineering: A Case of ‘Othering’?,” in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual On line: ASEE Conferences, Jun. 2020, p. 34467. doi: 10.18260/1-2--34467.
[26] C. Bolding (Cj) and R. O’Hara, “WIP Unseen: Examining the Link Between Disability Status and Students’ Sense of Belonging in Undergraduate Engineering,” in *2024 ASEE*

Annual Conference & Exposition Proceedings, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 48280. doi: 10.18260/1-2--48280.

[27] M. Tsugawa, B. Webster, S. Solanki, A. Cuellar, and C. Spence, "Examination of Ableist Educational Systems and Structures that Limit Access to Engineering Education through Narratives," in *2022 ASEE Annual Conference & Exposition Proceedings*, Minneapolis, MN: ASEE Conferences, Aug. 2022, p. 41800. doi: 10.18260/1-2--41800.

[28] R. A. Miller and M. Downey, "Examining the STEM Climate for Queer Students with Disabilities," Journal of Postsecondary Education and Disability, vol. 33, no. 2, p. 169-181.

[29] S. Salvatore, C. White, and S. Podowitz-Thomas, "'Not a cookie cutter situation': how neurodivergent students experience group work in their STEM courses," *Int. J. STEM Educ.*, vol. 11, no. 1, p. 47, Sep. 2024, doi: 10.1186/s40594-024-00508-0.

[30] S. Varadhan *et al.*, "Opportunities and Barriers to UDL-Based Course Designs for Inclusive Learning in Undergraduate Engineering and other STEM Courses," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore, Maryland: ASEE Conferences, Jun. 2023, p. 43797. doi: 10.18260/1-2--43797.

[31] A. Mouallem, T. Kulkarni, and S. Sheppard, "Leveraging the CARE Methodology to Enhance Pedagogical and Institutional Support for Blind or Low-Vision (BLV) Learners in Electrical and Computer Engineering (ECE)," in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 47746. doi: 10.18260/1-2--47746.

[32] E. Cech, "Engineering's Systemic Marginalization and Devaluation of Students and Professionals With Disabilities," in *2021 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual Conference: ASEE Conferences, Jul. 2021, p. 37080. doi: 10.18260/1-2--37080.

[33] Y. Weatherton, S. Daza, and V. Pham, "Perceived Barriers to Participation in Engineering:," in *2011 ASEE Annual Conference & Exposition Proceedings*, Vancouver, BC: ASEE Conferences, Jun. 2011, p. 22.1149.1-22.1149.18. doi: 10.18260/1-2--18886.

[34] N. Pearson, A. Godwin, and A. Kirn, "The Effect of Diversity on Feelings of Belongingness for New Engineering Students," in *2018 IEEE Frontiers in Education Conference (FIE)*, San Jose, CA, USA: IEEE, Oct. 2018, pp. 1–7. doi: 10.1109/FIE.2018.8658443.

[35] M. A. Pfeifer, J. J. Cordero, and J. D. Stanton, "What I Wish My Instructor Knew: How Active Learning Influences the Classroom Experiences and Self-Advocacy of STEM Majors with ADHD and Specific Learning Disabilities," *CBE—Life Sci. Educ.*, vol. 22, no. 1, p. ar2, Mar. 2023, doi: 10.1187/cbe.21-12-0329.

[36] A. E. Zaghi, A. Grey, A. Hain, and C. M. Syharat, "'It Seems Like I'm Doing Something More Important'—An Interpretative Phenomenological Analysis of the Transformative Impact of Research Experiences for STEM Students with ADHD," *Educ. Sci.*, vol. 13, no. 8, p. 776, Jul. 2023, doi: 10.3390/educsci13080776.

[37] E. Schearer, A. Reinthal, and D. Jackson, "Physically Disabled Students in Summer Undergraduate Research Environments," *IEEE Trans. Educ.*, vol. 65, no. 2, pp. 156–166, May 2022, doi: 10.1109/TE.2021.3101401.

[38] C. Groen, M. Paretti, L. McNair, D. Simmons, and A. Shew, "Experiencing Disability in Undergraduate Civil Engineering Education: An Initial Examination of the Intersection of Disability and Professional Identities," in *2018 CoNECD - The Collaborative Network for Engineering and Computing Diversity Conference Proceedings*, Crystal City, Virginia: ASEE Conferences, Apr. 2018, p. 29536. doi: 10.18260/1-2--29536.

[39] R. Figard, J. Bekki, and S. Brunhaver, “Disentangling the Intersectional Identities of Disabled Women in Engineering Programs through Narrative Inquiry (WIP),” in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 47196. doi: 10.18260/1-2--47196.
[40] M. Scheidt and A. Godwin, “A narrative approach to understanding underrepresented students’ pathways into engineering,” in *2017 IEEE Frontiers in Education Conference (FIE)*, Indianapolis, IN: IEEE, Oct. 2017, pp. 1–5. doi: 10.1109/FIE.2017.8190518.
[41] J. Amos, Z. Zhang, L. Angrave, H. Liu, and Y. Shen, “A UDL-Based Large-Scale Study on the Needs of Students with Disabilities in Engineering Courses,” in *2021 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual Conference: ASEE Conferences, Jul. 2021, p. 36627. doi: 10.18260/1-2--36627.
[42] B. Xie, A. Oleson, J. Everson, and A. J. Ko, “Surfacing Equity Issues in Large Computing Courses with Peer-Ranked, Demographically-Labeled Student Feedback,” *Proc. ACM Hum.-Comput. Interact.*, vol. 6, no. CSCW1, pp. 1–39, Mar. 2022, doi: 10.1145/3512912.
[43] D. Robertson, L. Williams, K. Avitabile, and D. Boyer, “WIP: Understanding the Experiences of Neurodivergent Learners in Engineering and Computing Majors,” in *2024 ASEE Annual Conference & Exposition Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2024, p. 48324. doi: 10.18260/1-2--48324.
[44] R. Figard and A. Carberry, “Virtual Learning Accessibility Barriers Experienced by Engineering Students with Disabilities in the Wake of the COVID-19 Pandemic,” in *2022 IEEE Frontiers in Education Conference (FIE)*, Uppsala, Sweden: IEEE, Oct. 2022, pp. 1–4. doi: 10.1109/FIE56618.2022.9962642.
[45] M. A. Pfeifer, E. M. Reiter, M. Hendrickson, and J. D. Stanton, “Speaking up: a model of self-advocacy for STEM undergraduates with ADHD and/or specific learning disabilities,” *Int. J. STEM Educ.*, vol. 7, no. 1, p. 33, Dec. 2020, doi: 10.1186/s40594-020-00233-4.
[46] S. Langley-Turnbaugh, J. Whitney, L. Lovewell, and B. Moeller, “Benefits of Research Fellowships for Undergraduates with Disabilities,” *Council on Undergraduate Research Quarterly*, vol. 35, no. 2, p. 39-45, 2014.
[47] M. J. Page *et al.*, “The PRISMA 2020 statement: an updated guideline for reporting systematic reviews,” *BMJ*, p. n71, Mar. 2021, doi: 10.1136/bmj.n71.
[48] S. Lawton Henry, Ed., “Web Content Accessibility Guidelines (WCAG) 2.2,” W3C Web Accessibility Initiative (WAI), Oct. 5, 2023. [Online]. Available: https://www.w3.org/TR/WCAG22/#abstract.
[49] “Nondiscrimination on the Basis of Disability; Accessibility of Web Information and Services of State and Local Government Entities,” *Federal Register*, 2024.

Appendix A: *PRISMA Flow Diagram for Reporting Scoping Literature Reviews [47]*