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# Is Neurodiversity Addressed as a [Hidden] Dis/ability in Engineering Education? A Literature Review*

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Supporting students with diverse abilities in engineering education is increasingly recognized as vital for inclusivity in STEM fields. This narrative literature review synthesizes research on how disability is addressed in engineering education, focusing on supportive frameworks, barriers, and effective practices. Disabilities can encompass a range of physical, cognitive, and mental conditions which may be more or less apparent. This paper focuses on developmental and cognitive conditions that have been termed neurotypes. Some neurotypes like autism and attention deficit hyperactivity disorder (ADHD) are considered hidden disabilities. These conditions are often viewed from a deficit perspective, utilizing medical diagnostic frameworks. The neurodiversity framework promotes recognizing strengths rather than deficits, aligning with Universal Design for Learning (UDL) to support diverse learners. Critical Disability Theory (CDT) further analyzes disability by questioning the societal norms that define neurodivergent traits as impairments. Barriers to participation include systemic inequities, prejudicial treatment, and ability tracking, which can stigmatize students and limit their access to rigorous engineering curricula. Effective practices, such as implementing UDL principles and promoting exploratory learning, can enhance engagement among students. Robust support systems are also essential, particularly during the transition from K-12 to postsecondary education. To overcome these challenges, it is critical to raise awareness of the individual nature of abilities and disadvantages, ensuring educators recognize and accommodate the unique needs of each student. In conclusion, addressing the needs of neurodivergent students in engineering requires a multifaceted approach that embraces inclusive pedagogical practices. We conclude the literature review by providing recommendations for educators on implementing strategies to support diverse learners in their engineering courses.

**Keywords:** neurodivergence; asset framework; accommodations

## 1. Introduction

Supporting students with different abilities in engineering education has gained increasing attention in recent years, driven by a recognition of the need for inclusivity and equitable access to STEM fields. This narrative literature review synthesizes current research on how [hidden] dis/ability[1] is addressed in engineering education, highlighting the importance of supportive frameworks, prevalence among college students, appropriate accommodations, barriers, and effective practices. Hidden dis/ability is a term used to indicate conditions that are not readily apparent, also variously termed invisible or non-apparent disability [3, 4]. Neurotypes like attention deficit hyperactivity disorder (ADHD), for example, are not externally obvious and some may be dis/abilities under select conditions.

Efforts have been devoted to help increase the extent to which engineering students are representative of the demographic diversity of the population. This initially focused on gender, and more recently race/ethnicity. These efforts are often termed Diversity, Equity, and Inclusion or DEI. However, comparatively little attention has been focused on dis/abilities and/or different neurotypes within DEI. For example, a search in Web of Science found only 105 articles from a topic search on "engineering education" AND "disability" compared to 1,615 articles on "gender" (1986 to present), 372 on "race" (1980 to present), and 196 with "ethnicity" (1993 to present).

The two textbooks related to engineering education research lack substantive treatment of disability topics. In the 2014 *Cambridge Handbook on Engineering Education Research* [3], one of the six sections focused on pathways into diversity and inclusiveness and yet the index identifies only a single mention of disability in the entire book. About ten years later there was a similar lack of attention on disability and different neurotypes in the 2023 *International Handbook of Engineering Education Research* (IHEER) [4]. The term 'disability' does not appear in the index and across the nearly 700 pages a word search found only 3 mentions. The first context included disability as a form of diversity, while the second context was largely focused on physical disabilities. The lack of engagement with issues around disabilities in these books is notable.

[1] Spelling dis/ability with a slash is intended to disrupt the deficit connotation of disability, acknowledging that social systems define whether particular physical, neurological, and psychological conditions impart disadvantages or advantages; see further explanation in Section 3.


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There is a need to understand how [hidden] dis/ability is perceived and addressed in engineering education. This paper fulfills this need by conducting a narrative literature review of [hidden] dis/abilities and neurodivergence to answer the following questions:

1. How has [hidden] dis/ability been defined?
2. How is [hidden] dis/ability conceptualized within theoretical frameworks in higher education?
3. What is the prevalence of neurodivergent individuals within the engineering student population?
4. What is the effectiveness of accommodation for engineering students?
5. What barriers hinder the full participation of neurodivergent students in higher education
6. What strategies have been employed to integrate neurodiversity within engineering education?

## 2. Method

The authors elected to employ a narrative literature review to synthesize relevant information in order to address the questions posed in this study. This synthesis of knowledge has been informed by several research endeavors, including investigations into neurodiversity within the context of innovation among engineering students [5], the impact of neurodiversity on the experiences of students enrolled in a first-year engineering projects course [6], and the development of a proposal to study neurodiverse students in engineering teams. Furthermore, the authors' personal experiences as the parents of neurodiverse children have also contributed to this understanding.

The broad nature of the questions addressed in this paper is well-suited to the narrative review approach, as it facilitates the integration of insights from disability studies, higher education literature, and specifically engineering education. In addition, although the Web of Science (WoS) search identified only 105 relevant articles, a Google Scholar search using the terms "engineering education" AND "disability" yielded 20,900 papers, while the more focused query "engineering education" AND "neurodiversity" yielded 669 results. The sheer volume of potential sources presents a significant challenge for a thorough examination. Consequently, rather than undertaking a systematic review, the authors exercised discretion in the selecting resources for inclusion. In many instances, numerous articles address a specific topic (e.g., comorbidities among conditions). As a result, we curated a limited number of references to support each point made in this paper. These selected articles frequently consist of literature reviews and synthesis papers, which can guide readers toward more comprehensive information on the respective topic.

The publication dates for the 105 disability papers identified from the Web of Science (WoS) search are compared to the 123 papers referenced in this study in Fig. 1. While the narrower scope of the WoS search yielded papers from 1993 to 2025, the supporting literature for the narrative review spans 1985 to 2025. A significant portion of the references, specifically from the years 2021 to 2024, accounts for 43% of the WoS papers and 45% of the citations in this review. This concentration of recent publications is salient, reflecting the recent emergence of the asset-based neurodiversity framework and evolving diagnostic criteria, as well as the increased attention directed towards Autism Spectrum Disorder (ASD) and ADHD.

The authors of the 105 papers identified from the WoS search represent 32 different countries, indi-

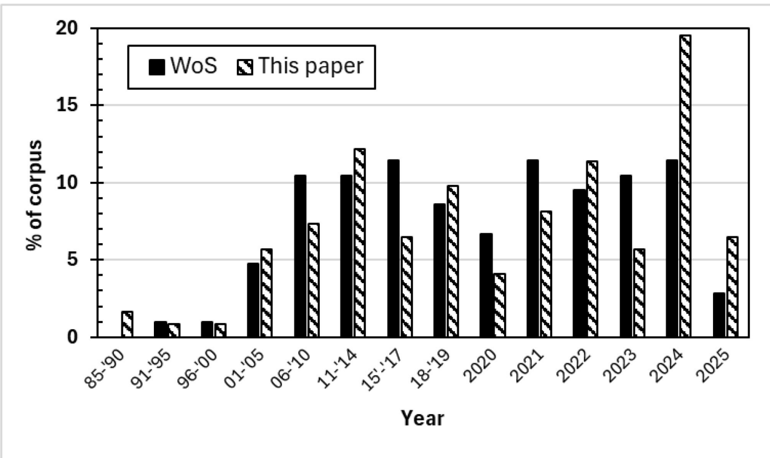


**Fig. 1.** Publication years of 105 papers from Web of Science (WoS) search and the 123 included in this literature review.

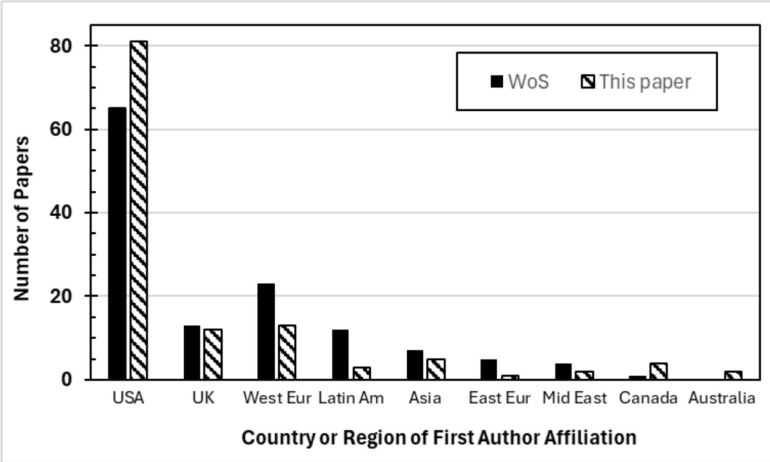


**Fig. 2.** Geographic distribution of author affiliations for the WoS corpus and the articles included in this narrative review.

cating a global interest in the intersection of engineering education and disability. In contrast, this literature review encompassed 123 articles authored by researchers from a smaller number of countries (n = 18). It is important to note that this count reflects the affiliation of the first author, and several papers featured international author teams (e.g., [7] UK, Austria, Spain, Germany, Netherlands). The geographic distribution of author affiliations for both the WoS corpus and the articles included in this narrative review is illustrated in Fig. 2. It is noteworthy that the majority of the countries exhibited four or fewer publications; consequently, these were clustered with nearby countries into broader regions. The predominant contributions emerged from authors based in the USA (62% in the WoS corpus and 66% in this review), the UK (12% in the WoS corpus and 10% in this review), and various Western European countries (22% in the WoS corpus and 11% in this review). Additionally, there were a few papers from Latin American, Asian, Eastern European, Middle Eastern, and other high-income Anglophone countries (i.e., Canada, Australia).

## 3. Describing Dis/ability

Dis/ability includes any deficiency in one or more abilities that interferes with an individual's performance of daily activities and participation in society [8]. Dis/ability represents a convergence of an individual's unique physical, cognitive, and mental health abilities with social structures that may result in disadvantages. Disabilities can manifest as temporary or episodic, with temporary disabilities potentially resolving completely with appropriate treatment (e.g., a broken leg). In contrast, episodic disabilities, such as those seen in multiple sclerosis and various mental health conditions, have symptoms that fluctuate unpredictably [9, 10]. In a study by Seymour and Hunter [11], approximately one-third of the students with disabling conditions had acquired at least one of their disabilities as adults, largely due to automobile or work accidents and illnesses (e.g., stroke, cancer). Consequently, these conditions require ongoing adaptive strategies at individual and organizational levels for effective management [8, 10]. Some forms or manifestations of dis/abilities can be readily apparent, such as using a wheelchair or cane due to physical mobility challenges, while others may be less visible as is the case with most neurologic and cognitive conditions. These 'less visible' conditions are variously termed invisible, non-apparent, or hidden disabilities [1, 2]. Individuals have the autonomy to disclose or withhold information about their condition in specific settings. The choice to withhold private medical information, thereby maintaining confidentiality (i.e., hidden), presents an ethical dilemma with both positive and negative ramifications within higher education. Additionally, students and adults may also choose to actively mask or camouflage their dis/abilities, largely in response to prevalent ableism and the perceived stigma associated with their condition [12–15]. These choices with respect to disclosure are most relevant for conditions that are not readily apparent.

A qualitative study on disability was conducted at the University of Minnesota (UM) during 1993-1994 [16]. UM was noted for graduating STEM students with disabilities at a rate significantly above the national average. The report documents a steady increase in the percentage of undergraduate students with disabilities in the UM Institute of Technology, starting from 0.4% among first-year students to 3.5% in the fourth and fifth years. Of the 65 students interviewed, 20 had more than one disabling condition. Furthermore, 75% of the interviewees had one or more disabling conditions that were 'hidden' or not readily apparent. A key finding was that all the students with disabilities (regardless of whether it was physical, cognitive, or other) were "time disadvantaged," with specific challenges varying based on the type of disability. For example, students reported issues such as "problems with concentration, pain, fatigue, and intellectual processing problems. . . . periods of time when they are partly, or wholly, incapacitated by their health condition, or its treatment" [16]. Among the students, those majoring in STEM fields were perceived to face fewer disadvantages compared to arts or social science majors, particularly for students with 'learning disabilities' (e.g., neurodivergence). The study also identified a tendency among instructors to perform a "lay diagnosis" of students, even when presented with a formal request for "reasonable accommodation" from the Disability Services Office, as mandated by the Americans with Disabilities Act of 1990.

Recent literature reviews have explored disabilities and neurodiversity in STEM and engineering education [17–21]. Studies show that neurodiverse youth with autism and ADHD are more likely to choose STEM majors than their neurotypical peers, indicating a unique alignment with STEM disciplines [11, 12] as they bring unique strengths like creative problem-solving and enhanced visual-spatial reasoning [13, 14]. However, they often face challenges due to deficit-based paradigms and standard assessments that limit their participation [20, 21]. Thus, this literature review will primarily focus on neurological conditions, such as autism and ADHD, rather than encompassing other forms of disability such as physical disabilities (like cerebral palsy or mobility impairments) and sensory disabilities (such as blindness or deafness).

## 4. How [Hidden] Dis/ability is Conceptualized: Difference in Frameworks

Differing abilities among individuals are often framed from a deficit perspective rather than an asset-based one, with the term "disability" symptomatic of this mindset. The categorization of neurological and cognitive differences in engineering education is a complex issue that intersects with various medical frameworks, including the Diagnostic and Statistical Manual of Mental Disorders (DSM) from the American Psychiatric Association and the International Classification of Functioning, Disability, and Health (ICF) from the World Health Organization [22–25]. This literature review explores how these classifications influence the understanding and support of students with different abilities in engineering contexts, with a summary of these frameworks presented in Table 1.

The DSM provides a framework for diagnosing

**Table 1.** Comparative Table: conceptualizations of disability and ability in engineering education

| Framework | Primary Focus | Core Orientation | How Ability/Disability Is Conceptualized | Implications for Engineering Education | Limitations / Critiques |
|---|---|---|---|---|---|
| **DSM** (Diagnostic and Statistical Manual of Mental Disorders) | Diagnosis and classification of mental & neurodevelopmental disorders | **Medical / Deficit-Based** | Disability as a clinically diagnosable disorder (e.g., ADHD, ASD, Dyslexia); fixed, categorical, symptom-based | Can guide individual accommodations and formal diagnoses; widely used in healthcare and some education settings | Risk of pathologizing difference; evolving criteria; may not align with educational needs or reflect full lived experiences |
| **ICF** (International Classification of Functioning, Disability, and Health) | Interaction between health condition, environment, and participation | **Biopsychosocial / Contextual** | Disability as a result of interaction between individual limitations and environmental/social barriers | Encourages identification of barriers in learning environments; supports inclusive design at systemic levels | Requires systemic assessment; less widely understood or applied in the U.S. education systems |
| **CDT** (Critical Disability Theory) | Social, political, and cultural critique of how disability is constructed | **Critical / Justice-Oriented** | Disability as a social construct shaped by power, stigma, and exclusion; critiques norms and systems | Encourages reflection on norms in engineering education, values student voice, and supports systemic transformation | Abstract and theory-heavy; not easily operationalized without deep faculty engagement and reform efforts |
| **UDL** (Universal Design for Learning) | Educational design that supports diverse learners | **Asset-Based / Inclusive Pedagogy** | Disability reframed as variability in learning; diversity is expected and normal | Promotes flexible teaching methods, multiple modes of access, expression, and engagement; supports all students | May be inconsistently implemented; requires institutional commitment and training |

neurodevelopmental disorders (including Attention-Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD)) and specific learning disorders (SLDs), such as Dyslexia and Dyscalculia. Both of these types of conditions can significantly impact students' educational experiences. Understanding the specific types of symptoms and effects are crucial for educational planning and intervention [26]. However, the application of DSM criteria in educational settings can lead to confusion and inconsistency, as school personnel often rely on different classification systems, such as the Individuals with Disabilities Education Act (IDEA). This discrepancy can complicate the identification and support of students with disabilities in engineering programs, as educators may not fully understand the implications of these classifications on students' learning needs and potential [26]. Different conditions can manifest differently, creating unique learning challenges. In addition, there is not even consensus within the medical community on appropriate diagnosis for many neurodevelopmental disorders and the diagnostic markers continue to evolve over time. The DSM-5-TR made updates in 2022, from the previous DSM-5 in 2013 (ASD characterized), DSM IV in 1994 (Autism grouped into 5 subtypes; ADHD grouped into 3 subtypes), DSM-II-R in 1987 (when the term ADHD was first used), the DSM-III in 1980 (Autism recognized as a distinct developmental disorder; ADD with or without hyperactivity), and so on. These various conditions are increasingly recognized as existing on a spectrum of manifestations, neural structures, and genetics (27-28).

The ICF framework offers a more holistic approach to understanding disability by emphasizing the interaction between health conditions and contextual factors. It categorizes disability as a complex interplay of medical impairments, activity limitations, and participation restrictions [11]. This perspective is particularly relevant in engineering education, where the focus on functional abilities can help create more inclusive learning environments. Use of the ICF can facilitate a more nuanced understanding of how disabilities affect students' learning experiences in engineering. For example, it allows educators to more readily identify the environmental and social factors that may hinder or support the success of students with disabling conditions.

Neurodiversity is a theory, framework, and/or paradigm that rejects the deficit language of disability and embraces the stance that individuals can self-identify [29, 30]. Neurodivergence (ND), encompassing ADHD, ASD, Dyslexia, and Dyspraxia, affects a significant portion of the population [231]. The neurodiversity framework aligns with the principles of Universal Design for Learning (UDL), which advocates for flexible learning environments that accommodate diverse learners [32]. Another example of an asset-based framework is Critical Disability Theory (CDT), which analyzes disability as a cultural, historical, relative, social, and political phenomenon [33, 34]. The term dis/ability as proposed by Goodley [35] aligns with CDT and interrupts the binary and uncontested notion of disability. This framing asks questions such as "what do neurodivergent engineering students have?", rather than "what do ND engineering students need?" [36] CDT scrutinizes the social norms that define particular attributes as impairments, as well as the social conditions that concentrate stigmatized attributes in particular populations [37].

## 5. Prevalence of Neurodivergent Individuals in the Engineering Student Population

Historically, faculty and students may have believed that individuals with disabilities, and particularly those that manifest as learning disabilities, would not be admitted to engineering majors in college. However, the asset-based approach to neurodiversity challenges the deficit models that have traditionally characterized these conditions as merely learning disabilities.

Recent studies have found that approximately 38% of engineering undergraduate students self-identify as neurodivergent (including those who indicated "yes" or "maybe" to a self-report survey), including first-year students to seniors [38, 39]. This percentage is somewhat higher than the range reported for college students more generally. The large *American Freshman* study from the Higher Education Research Institute (HERI) at UCLA, surveyed 33,039 full-time first-year students and found the following prevalence of ND and medical conditions: 20.7% psychological conditions (depression, PTSD, etc.), 13.2% ADHD, 5.5% learning disability (e.g., dyslexia), 4.1% chronic illness (cancer, diabetes, autoimmune disorders, etc.), and 2.1% ASD [40]. Because co-morbidities were not identified, the percentage of first-year students who are neurodivergent could be 20% or more (since some psychological conditions are sometimes considered types of ND, such as anxiety). Mak et al. [41] reported that 18.8% of college students in the U.S. had ADHD (higher than the HERI data). ADHD diagnosis has increased over time, although it is unclear the extent to which environmental factors or diagnostic changes might account for these differences [42].

*Comorbidities.* It has been reported that half of the college students with ADHD had another condition (commonly generalized anxiety disorder, major depressive disorder) [41]. Hotez et al. [43] found that feelings of depression among first-year college students were experienced at a higher among those with ADHD compared to students without ADHD. A study using the HERI data from 2012, 2014, and 2016 and over 2,000 incoming first-year students who identified as ASD found that 31% also had ADHD [44].

*Demographic Differences*. The prevalence of various neurotypes may vary among different genders or race/ethnic groups. The large HERI study found that a higher percentage of male than female students identified as having ADHD and ASD [40]. It is believed that ADHD is under-diagnosed in females and minoritized individuals [42]. The study among engineering students found that more male than female students identified as neurotypical; among the few students who identified their gender as not male or female, the self-identification as neurotypical was the lowest [28]. This trend matches the trends for undergraduate students with disabilities in 2019–2020 reported by the National Center for Education Statistics (NCES): 17.6% of males, 21.9% of females, and 53.7% of nonbinary students [45]. Among first-year engineering students a higher percentage of Asian students identified as neurotypical compared to White students [28]. This trend again matches national data on disability among undergraduate students more generally from the NCES, where 13.9% of Asian students compared to 21.1% of White students had a disability.

*Medication Effects*. While it is common to prescribe stimulant medication to treat ADHD, studies have found that the use of this medication does not "normalize" the learning and academic performance of students with ADHD [44]. Medications for autism are primarily used to reduce symptoms like irritability, aggression, and anxiety, which can indirectly help a child engage in learning activities [47]. However, there is limited evidence showing a direct positive impact on academic performance. Additionally, these medications can have side effects such as sedation, cognitive impairment, weight gain, and metabolic disturbances, which may disrupt a child's academic functioning [48]. On the other hand, addressing anxiety that co-occurs with autism – since it can negatively affect factors like sustained attention and school participation – might provide indirect support for better academic outcomes [49]. Some college students may also choose not to take prescribed medication [50]. Overall, it should not be assumed that medical treatments alleviate the need for academic accommodations.

## 6. Re-evaluating Intellectual Abilities: Exploring Unique Cognitive Strengths

In the qualitative study by Seymour and Hunter we hear about the unique positive abilities of some of the students who were characterized as having 'learning disabilities', including picturing things in their head, spatial skills, and being detail oriented [11]. One of the quotes alludes to problems that the student might encounter when instructors require him to 'show his work' in writing; e.g., "Something innate back there is working just fine. And I can't always tell you how I know it." (p. 39). The authors state, "learning disabilities are often mistaken for poor intellectual ability, whereas they may equally affect people who are intelligent and gifted" (p. 40), further reinforcing this idea by discussing these issues found among STEM graduate students and a post-doctoral science fellow.

It has been asserted that diversity drives innovation, including disability [51]. For example, White and Shah [52] found that adults with ADHD scored "higher in originality, novelty, and flexibility" compared to peers without ADHD, indicating a potential correlation with aspects of innovative thinking. White [53] also discussed multiple examples of creativity and divergent thinking that are higher among individuals with ADHD. Some studies have linked ADHD and entrepreneurship [54, 55]. A number of famous leaders and innovators in STEM fields have atypical neurotypes, including Bill Gates (dyslexic, ADHD), Steve Jobs (dyslexic), and Albert Einstein (traits associated with autism, dyslexia, and/or ADHD) [56, 57].

In an innovation-oriented class intervention [58] focused on innovative behaviors and cognitive skills using Dyer's innovator's model [59], students in an engineering course completed five short reflective memos throughout the semester, comprising two individual assignments and three team assignments [60–62]. The depth scores of these reflective memos were compared. The individual learning depth scores in their reflective memos were similar between ND and NT students, collaborative group submissions suggested that team-based environments may support stronger innovative outcomes for teams of mixed neurotypes [5].

## 7. Effectiveness of Accommodations for Neurodivergent Engineering Students

The academic accommodations process at higher education institutions is generally controlled centrally via a Disability Services Office (DSO) and therefore basic processes will not differ among academic majors at the institution. The framing as Disability to receive accommodations is sometimes avoided by students. Students with a temporary disability (e.g., from a car accident) may not understand that DSO can help them, perceiving themselves as having injuries rather than disabilities. Students who view their condition as a neurotype (e.g., ADHD) may also avoid characterizing themselves as disabled. The accommodations process for STEM students in higher education has been synthesized in a number of different literature reviews [63, 64].

In tracing the history of accommodations in higher education, Gelber starts with the emergence of the concept of 'learning disabilities' (LDs) in the 1960s and notes that the white middle class initially embraced this idea that children of average or better intelligence might struggle to succeed in school based on classroom conditions and teaching practices [65]. Higher education had developed accommodations for military veterans who had become disabled and were attending college under the GI Bill. Federal regulations prohibiting discrimination of disabled individuals in education were first enacted in 1973 (i.e., Section 504 of the Rehabilitation Act) which was later clarified to require "reasonable accommodations." In the mid 1980s a number of institutions began to create formal policies related to LDs, and typical accommodations included extra time on assignments, alternative testing arrangements, recorded lectures, and exemptions from course requirements for world languages. Systems tended to balance students taking on responsibility and instructor accommodations and emphasized that educational standards were not being lowered. The 1990 Americans with Disabilities Act (ADA) expanded these protections, but as more students entered college requesting accommodations faculty pushback began to grow. Amendments to the ADA in 2008 clarified that disability was not narrowly defined and provided broad protections.

In the United States, data indicates that approximately 25% of students at selective colleges receive accommodations, compared to about 6% at community colleges [65]. Furthermore, only 21–32% of disabled college students obtain academic accommodations [39]. In one study, 11%, 22%, and 50% of neurodivergent students in three junior and senior-level environmental engineering courses received accommodations. In contrast, at a different institution, none of the 14 neurodivergent students in an electrical engineering course requested formal accommodations [39]. Even among students who are approved for accommodations, some do not utilize them in their courses. In a study focusing on students diagnosed with ADHD who also consumed alcohol and had obtained academic accommodations, it was found that these accommodations were used in an average of 62% (SD = 36) of their courses [66]. The main reasons for not using the accommodations included perceiving them as unnecessary, finding them difficult to use, and discomfort with approaching instructors [66]. Although students who received and utilized accommodations reported finding them as beneficial, no objective measures verified over students with ADHD who did not receive academic accommodations. The usefulness of accommodations may vary, depending on the condition, needs, class requirements, and specific accommodations received. Tuffy et al. [66] assert that most studies have not found positive effects of accommodations for students with ADHD (such as extended time on exams, distraction-free testing environments), while others characterize the accommodations for students with ADHD as helpful but insufficient. In [67], Sarrett conducted a study based on the survey responses of 66 adults who identified as autistic and attended a higher education institution, along with follow-up focus groups with 31 of the participants. Among the survey respondents, 62% received accommodations; some who did not obtain accommodations were not diagnosed until after college. While over half of those receiving accommodations reported that they met their needs, others did not feel the accommodations "addressed[ed] their sensory, social, academic, or psychiatric needs" (p. 685). Even among those who gave positive responses about their accommodations, some noted inconsistent implementation and that not all of their professors complied. Some noted a need to constantly advocate for themselves with faculty despite officially granted accommodations.

Grimes et al. found that among those with learning disabilities (which was a classification that included ADHD, dyslexia, and ASD) who did not disclose their condition and therefore do not seek accommodations at an institution in Australia, the reasons were most commonly: they developed their own strategies for dealing with their learning challenge (68%), did not think the help offered would be of any use to them (58%), they did not want to be treated differently by their lecturers and tutors (36%), did not know there was any assistance (29%), and did not need help from the university with their studies (21%) [668. Accommodations desired by autistic adults that were not frequently addressed included: sensory friendly spaces and practices and allowing self-stimulatory behavior (such as rocking back and forth) [67]. A sensory escape room could offer an environment with low light, minimal noise, and no strong odors, while also providing a private space where stimming behaviors are accepted. Creating an optimal learning environment for everyone in a classroom poses challenges, as low lighting might cause visual difficulties for some, ideal noise levels vary, and movement can be distracting to others. Therefore, a balanced approach involving tools like sunglasses, headphones, or preferred seating arrangements during class, options for remote participation, and designated sensory break areas could help accommodate diverse sensory needs, fostering a focused and inclusive learning atmosphere.

The types of accommodation desired were not always individual. Sarrett found that focus group participants wanted more autism awareness on campus, and associated training of professors, staff (including advising, security, and medical), and peers. They reinforced the idea that each person has different needs, associated with different strengths and weaknesses [67]. Therefore, everyone needed to understand that listening to individuals was important. A disability support group was another idea that extended beyond the individual accommodations approach. The group could be virtual (online) and/or in-person, allowing networking, sharing experiences, and ideas. Seymour and Hunter found in their interview study with disabled students that most preferred not to disclose their condition, only doing so in order to receive accommodations [11]. Even so, many feared that classmates and/or faculty would have adverse reactions due to unfairly receiving test accommodations. Thus, faculty should help students avoid classmates' awareness of their testing and other accommodations.

Dwyer et al. [69] proposed several recommendations for improving accommodations for individuals with disabilities. They suggest centralizing all accommodations for classrooms, housing, and student employment into a single point of contact. The authors also emphasize the need for increased flexibility in disability documentation requirements, noting the financial burden and time constraints associated with obtaining recent evaluations, especially given the inconsistent quality of neuropsychological assessments available from various providers. Furthermore, they recommend addressing sensory discomfort and distractions in housing and dining, which includes considerations for lighting, temperature, noise, and odors. Transition support programs, such as summer bridge initiatives, first-year check-ins, mentorship opportunities, and social skills training are also highlighted as crucial for students' successful adjustment to college life. Additionally, they stress the importance of providing enhanced mental health support, given the high comorbidity rates of anxiety, depression, and suicidality among neurodiverse individuals. This includes offering free counseling services with adequately trained clinicians who understand neurodiversity. Lastly, Dwyer et al. advocate for a system that ensures swift remediation when students are denied access to accommodations, which could include the assignment of case workers for personalized assistance [69].

Maul et al. [64] conducted a literature review that examined themes such as the impact of negative perceptions on students' willingness to disclose disabilities and request accommodations, the challenges in obtaining accommodations, and the ineffectiveness of some accommodations. For example, while students might receive extra time and a quiet setting for exams, this could prevent them from asking instructors questions during the exam. The review included around 46 papers focusing on higher education in the U.S., specifically excluding papers from non-STEM fields before the year 2000. However, the exact criteria used for selecting these papers were not clearly defined. The authors generally did not specify if the studies were specific to the field of engineering. One notable exception was a study indicating that engineering faculty members were less likely than faculty in other disciplines to grant student accommodations. Upon examining the primary source, it was determined that law faculty ($n = 10$) would grant an average of 10.22 accommodations out of 18 possible. Engineering faculty ($n = 29$) were slightly more accommodating, with an average of 10.51 accommodations. Both were lower compared to other disciplines in the study, with business faculty ($n = 22$) averaging 11.55 accommodations and education faculty ($n = 45$) at the highest with an average of 13.51 accommodations [70].

Moon et al. [63] conducted an extensive literature review, presented in a 224-page report, focused on accommodations for students in STEM fields ranging from middle school to collegiate levels. The report used the framework of students' 'functional abilities', rather than specific medical conditions. They looked at student issues, pedagogical issues, and solutions for different groups of functional abilities.

Singer et al. [71] conducted a longitudinal modeling study investigating a cohort of Israeli engineering students over a decade to examine the diagnosis of learning disabilities, students' background characteristics (such as entrance and high school test scores in mathematics, English, and physics; and gender), the accommodations afforded to them, and their academic performance in various courses. The study comprehensively analyzed 11 categories of learning disabilities and 11 types of accommodations (including, for example, 25% additional time, 50% additional time, oral reading of questions, utilization of formula sheets, and exemption from penalization for spelling errors). Withing the studied institution, typically two alternative accommodations were available for each specific type of learning disability. The model employed by the researchers enabled them to identify which accommodation option yielded better outcomes for specific learning disabilities, taking into account particular student background characteristics. The study provided examples where reading exam questions aloud proved to be a more effective accommodation than extra time for students with dyslexia, while students with ADHD generally performed better when granted extra time. Other institutions might consider developing similar models, provided retrospective data is available; however, it is uncertain whether U.S. institutions maintain comparable records detailing learning disability types and accommodations. Interestingly, in the U.S. standard extra time accommodations are typically set at 50% and 100%, while the option of reading exam questions aloud is relatively uncommon.

Furthermore, Harrison and Armstrong [72] were critical of the fact that all 49 of the Canadian Disability Services Offices in their study granted extra time accommodations for a fictitious student, despite lacking 'objective evidence supporting either an ADHD diagnosis or functional impairments'. The concern was that the system was overly lax by relying on student self-report and a neuropsychologist report that included behavior inventory ratings by the student and both her parents. This illustrates the challenge that DSOs face in trusting and believing students while providing fair accommodations that do not provide advantages to some students.

A systematic scoping review of academic accommodations was conducted to explore the higher education experiences of students with various types of medical conditions including mental health challenges and disabilities. The review encompassed 133 articles covering students from at least 36 countries, with some regions described collectively, such as EU or North Africa [73]. Several themes emerged concerning accommodations: some students were unaware of available accommodations; while others were reluctant to request them desiring to succeed independently or due to concerns about stigma – both self-imposed and anticipated from others. Additionally, the effectiveness of disability support services could be enhanced; current procedures were perceived as overly burdensome in terms of process, time, and costs associated with obtaining a formal diagnosis. Furthermore, instructors sometimes failed to properly implement the accommodation granted. The paper featured an exemplary table outlining individual course and assessment accommodations tailored to various needs, such as those related to executive functioning, self-regulation, and social interaction; these are common challenges associated with ADHD and ASD. The authors advocated this individualized approach over accommodations determined solely by medical diagnosis or condition category, to better address the unique needs of each student. For instance, the 'sawtooth' pattern of assets and deficits may vary significantly between individuals, and comorbidities can either exacerbate or alleviate typical symptoms.

## 8. Barriers That Hinder the Full Participation of Neurodivergent Students in Higher Education

Categorizations of disabilities can have significant implications for educational outcomes. Studies have shown that misclassification or overclassification of disabilities can lead to stigmatization and lower expectations from educators, which can adversely affect students' academic performance and career aspirations in engineering [74, 75]. One significant barrier to the participation of students with disabilities in engineering education is the systemic inequities that persist within educational structures. Research indicates that students with disabilities often face prejudicial treatment from peers and educators, which can hinder their academic success and persistence in STEM fields [76]. Furthermore, at the K-12 level students with disabilities are frequently placed in lower-level classes due to ability tracking, which limits their exposure to rigorous courses needed for admission to competitive engineering colleges (e.g., calculus), engineering curricula, and opportunities for engagement in hands-on learning experiences [77]. This tracking not only affects their learning outcomes but also reinforces negative perceptions about their capabilities in STEM [78].

Research by Jarvis and Nordmann indicates that ND students generally have lower well-being and academic self-efficacy than their NT peers, suggesting a need for enhanced support [79]. Research indicates that autistic individuals experience significantly lower levels of well-being and quality of life compared to neurotypical individuals [7, 80–82]. However, Nejeeb and Quadt challenge this perspective by employing a neurodiversity-affirmative framework, suggesting that well-being and quality of life are subjective experiences. They emphasize that what well-being looks like for each individual is particularly subjective within the autistic population, which encompasses a diverse range of strengths and challenges [83]. Treating neurotypes as a monolithic category may overlook important differences among conditions. For instance, ADHD, the most common neurodivergent condition in college settings, shares some traits with ASD, yet they differ significantly in areas such as executive function. While individuals with ADHD struggle with planning and inhibition, those with autism face challenges in cognitive flexibility [54]. Commonalities between ADHD and ASD include sensory sensitivities, higher rates of anxiety and depression, and differences in communication and social interactions [84]. Notably, ADHD individuals often seek novelty and struggle with attention regulation, while those with autism typically prefer routine and familiarity, resulting in distinct behavioral patterns. A study of seven STEM graduate students illustrates the range of visibility in neurodivergent conditions, many of which are invisible or less apparent; the visibility of these conditions can also shift over time, creating distinct challenges in academic environments, especially for neurodivergent students [85].

Neurodivergence might complicate students' experiences in team settings. The engineering curriculum is designed to enhance teamwork and design skills, aligning with ABET EAC Student Outcomes 5 and 2, respectively [86]. Many engineering programs incorporate hands-on, team-based design projects early in the curriculum, making these experiences crucial for students' self-efficacy and sense of belonging in engineering. Engineering design projects typically involve teams, where a mix of backgrounds and experiences can significantly impact design quality. Research indicates that teams with varied perspectives often foster creativity and innovation, enhancing problem-solving abilities [87–88]. For instance, teams composed of individuals with differences in cultural and national backgrounds often exhibit enhanced creativity and innovation [89, 90], and gender differences are linked to radical innovation [91]. Studies have also explored cognitive variation within teams and its relation to creativity and innovation [92]. While varied backgrounds can enhance design projects, they can also pose challenges such as communication obstacles and conflicts, which may impede collaboration [93]. Processes within teams, such as cognitive conflict, task conflict, team climate, leadership, and management, are also important considerations in innovation [94–97].

Teamwork requires various skills, including interpersonal communication, organization, and conflict resolution [98, 99]. Some neurodivergent conditions are associated with difficulties in these areas, including ASD which often impacts interpersonal communication [100], and ADHD which is linked to organizational challenges and lower social skills [101]. Zolyomi et al. [102] found that neurodivergent students in higher education struggle to express individual differences and address team conflict. Delp [103] discusses how teamwork is emphasized in first-year design courses, which may have significant implications for students with ASD. Additionally, teamwork in engineering extends beyond formal design settings to include laboratories and informal study groups, meaning that difficulties in collaboration can broadly affect students' grades, learning, success, and overall well-being [104].

## 9. Strategies and Innovative Approaches for Integrating Neurodiversity in Engineering Education

To address the institutional barriers to the success of neurodivergent students, several universities have started campus-wide initiatives. For instance, Vanderbilt University has fostered a neurodiversity-compatible campus through initiatives such as the Frist Center for Autism and Innovation, which opened in 2019, the Vanderbilt Autism & Neurodiversity Alliance (VANA), and the Neurodiversity Inspired Science and Engineering (NISE) Program for graduate students. These initiatives aim to support and empower neurodivergent students, faculty, and staff [105–107].

Initiatives are exploring moving beyond traditional accommodations for ND engineering students [108]. Several projects have been launched to "capture narratives" from ND engineering students through social media engagement. These projects utilize mixed methods and social media analytics to understand the students' strengths and challenges [109–110]. Recent research efforts also include developing a self-concept scale specifically for ND students in STEM fields [111], alongside explorations into informal STEM education and autism [112], and the role of artificial intelligence (AI) in supporting neurodivergent learners [113]. These studies collectively highlight the importance of addressing the unique needs and experiences of neurodivergent students to improve retention and success in higher education. The unique talents of these individuals can make important contributions to society via STEM fields.

To address the educational barriers, several studies advocate for the implementation of UDL principles in engineering education. UDL emphasizes the need for flexible learning environments that accommodate diverse learners, thereby enhancing accessibility and engagement [30, 114]. UDL emphasizes the importance of planning for learner variability, ensuring that all students, including those with disabilities, have equal opportunities to learn and demonstrate their knowledge [115]. Additionally, the integration of exploratory learning and real-world investigations has been highlighted as essential for promoting engagement among students with disabilities in STEM education [107]. However, it is important to listen to ND students and provide alternatives for engagement; for example, Durgungoz and Durgungoz [116] found that ND students preferred anonymous interactions due to sometimes finding group discussions overwhelming. Creating inclusive educational environments for ND students must also extend beyond course design issues to include the physical environment where learning occurs, taking into account sensory and social issues [117]. Moreover, the role of supportive educational practices is crucial in fostering an inclusive environment. Programs that focus on broadening participation, such as those implemented at the Center for Sensorimotor Neural Engineering, have shown promise in successfully including individuals with disabilities in significant roles within STEM [118]. These practices not only enhance the educational experience for students with disabilities but also contribute to a more diverse and innovative engineering workforce. The transition from K-12 to postsecondary education is another critical phase where students with disabilities often encounter challenges. Research indicates that many students with disabilities lack adequate support systems during this transition, which can lead to lower enrollment and graduation rates in engineering programs [119]. It is essential for educational institutions to provide targeted support and services to help these students navigate the complexities of higher education and pursue STEM careers effectively [120].

## 10. Discussion

An increasing number of students with diverse neurotypes are matriculating into engineering in college. There is an increasing interest in neurodiversity-affirmative perspectives in engineering education. Addressing the needs of students with different cognitive and neurological conditions in engineering education requires a multifaceted approach that includes systemic changes, the adoption of inclusive pedagogical practices, and the provision of robust support systems. It is crucial to adopt an anti-deficit theoretical framework. Critical theoretical frameworks will be helpful to provide empowerment and liberation for marginalized individuals [121–125]. By utilizing asset-based approaches, the learning of ND engineering students is promoted in meaningful and relevant ways.

Neurodivergent students should not be expected to disclose their medical conditions. In addition, co-occurring conditions and individual differences mean that each student is unique in their assets and situations that will pose challenges. Rather than forcing each student to receive formal accommodations through Disability Services Offices, which may or may not actually meet their needs, instructors can consider practices that support the success of all students. Engineering instructors can design their course with UDL principles in mind, providing diverse ways to facilitate student learning and enabling them to demonstrate their understanding. The course syllabus can counter deficit framing and reduce stigma by acknowledging that all students bring both assets and limitations into each educational setting. Additionally, the syllabus can make it clear that the instructor is committed to supporting each student in their unique learning journey. Establishing open communication and trust at the beginning of each course is essential.

To what extent can evaluation practices to ensure that learning objectives are met be flexible, allowing students the best opportunity to demonstrate their knowledge and skills? These assessments might vary across learning objectives, and an individualized approach between an instructor and the student may find the best solution, rather than relying on a non-specific accommodation that is expected to generically meet student needs (such as the common 'extra time' for exams). This process may be complicated for large classes that make it difficult to accommodate non-standard or more individualized outcomes assessment methods. Specific examples of UDL in large lecture classes have been published [126].

Engineering has the opportunity to use our design methods to find approaches that are suited to our needs (mapping to the ABET student learning outcomes, laboratory settings, etc.). These efforts could include students of varying neurotypes in course design processes, such as via participatory action research. It has been stated that disabilities result in an array of time disadvantages for students [16]. Perhaps this time burden can be more equally distributed to educators and educational systems.

## 11. Conclusions

This review underscores the critical importance of fostering inclusive and accessible environments within engineering education to support neurodiverse students. Institutions must move beyond deficit perspectives and embrace asset-based and neurodiversity-affirmative frameworks that recognize the unique strengths and challenges each student brings. Inclusive practices such as Universal Design for Learning, flexible assessment methods, and transparent communication can reduce reliance on formal disclosure and generic accommodations, thereby enhancing equity in engineering classrooms.

Supporting neurodivergent students is not solely a matter of fairness or compliance but a strategic investment in innovation. By creating systems that enable all students to thrive, engineering education can expand pathways for creativity, advance technological solutions, and contribute to broader societal and environmental benefits. Future research should explore the effectiveness of specific inclusive pedagogical practices and assessment models in diverse engineering contexts to inform evidence-based policy and instructional design.

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