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Examination of Ableist Educational Systems and Structures that Limit Access to Engineering Education through Narratives

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Keywords: neurodiversity, accessibility, critical analysis, learning disabilities, mental health

Abstract: The purpose of this paper is to examine how higher education systems limit access to engineering education for disabled and neurodivergent engineering students. Throughout this paper we will discuss ableism in higher education systems. Particularly, U.S. institutions and education are designed for non-disabled and neurotypical people rather than with accessibility for all despite legal efforts to improve access to education. We also provide two narratives from the authors that describe their experiences with having a disability and being neurodivergent in engineering education. Finally, we suggest other paradigms and methodologies engineering education researchers can utilize when conducting research on disability and neurodivergence in engineering.

A person is disabled not by their impairments, but by the failure of their environment to accommodate their needs. - [1, p. 271]

1. Introduction

According to the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), over 1 billion people from the world population [2] and approximately 26% of people in the U.S. live with some form of a disability [3]. WHO and the CDC measure and classify disability through six questions related to hearing, vision, cognitive, mobility, self-care, and independent living [4]. With such a large portion of the population classified with having a disability, there are still a disproportionate amount of people with disabilities participating in U.S. higher education approximately 11%, [5]. This lower participation rate may stem from systemic barriers within educational institutions that perpetuate ableism. Ableism “describes, and is reflected in, individual and group perceptions of certain abilities as essential” and “promotes ability preference” [6, p. 2].

The purpose of this paper is to examine the ableist structures of higher education that limit access to engineering education. In this examination, we present

- a definition of disability and neurodivergence,
- a brief history of ableist educational structures in the U.S., and
- engineering student narratives pertaining to their experiences with disability and neurodivergence in engineering education.

We then discuss pathways forward in engineering education for adapting more accessible pedagogical practices and paradigm shifts in disability and neurodiversity research design.

2. Disability and Neurodivergence

Disability is fluid and contextual rather than biological… disability, if understood as constructed through historical and cultural processes, should be seen not as a binary but as a continuum. - [7, pp. 210–211]

In this paper, we broadly discuss disability with a specific emphasis on neurodivergence (e.g., learning disabilities and mental health). We define disability and neurodivergence as natural physical, cognitive, and psychological human differences [8]. Disability encompasses both visible and invisible conditions (e.g., cerebral palsy, irritable bowel syndrome, anxiety, ADHD, bipolar disorder, etc.), occurs at early onset (e.g., Down's syndrome) or due to trauma (post traumatic stress syndrome), and chronic or acute. We chose these dimensions of disability to account for comorbidities and the lived experiences of individuals in our chosen context (engineering education). Further, we chose to focus on neurodivergence due to the limited and deficit-based published knowledge on how neurological conditions are defined.

2.1. Disability and Neurodivergence as a Social Model

On-going conversations around disability and neurodivergence are shifting the beliefs around knowledge on and reality of disabled and neurodivergent people within fields such as disability studies, clinical psychiatry, and psychology [9]–[14]. Particularly, researchers advocate for moving away from pathological models to a social model of disability and neurodiversity. The pathological model for disability and neurodiversity assumes such conditions can be and should be cured or eradicated [15]. This paradigm shift away from the pathological model to a social model focuses on "social oppression, cultural discourse, and environmental barriers" [13, p. 214] experienced by disabled and neurodivergent people. The social model advocates for the necessary treatments needed while also accepting their disability identity as a part of a person. Shakespeare [13, p. 216] defines three dichotomies that distinguish disability and neurodiversity as a social model:

1. "Impairment is distinguished from disability."
2. "The social model is distinguished from the medical [pathological] model."
3. "Disabled people are distinguished from non-disabled people."

For the first dichotomy, Shakespeare argues that disability is public and structural because it is socially constructed within society. The goal is to remove disability from educational systems that limit participation of disabled students while accepting individual impairments. The second dichotomy conceptualizes how medical model thinking simplifies disability in terms of numbers and medical prevention (e.g., cures and rehabilitation), Shakespeare argues that the medical model of disability is reactionary and based in deficits. A social model approaches disability with the goal of systemic change for accessibility and reduction of social oppression. Shakespeare's third point indicates that non-disabled people should not be the voices of disabled people. We need to hear from disabled people and their experiences for the best insights on how to understand disability and remove oppression. An example includes the organization Autism Speaks, an organization ran by allistic (non-autistic) people whose main goal is to cure autism. With the emergence of the neurodiversity movement, many autistic autism advocates criticize this group saying the group supports eugenics of autistic people [16]. The autistic autism advocates promote that "autism and other neurological conditions are natural variant of human neurological outcomes — natural difference, rather than disorder" [10, p. 56].

Although the social model of disability aims to lift disability oppression, Shakespeare recognizes weaknesses in the model [13]. For example, the social model may lead non-disabled people to believe that impairment is not important resulting in neglect. Further, another weakness is the difficulty in distinguishing "impact of impairment and the impact of social barriers" because it is the "interaction of individual bodies and social environments which produces disability" [13, p. 218]. The point of the social model of disability is to remove the structural barriers that limit the participation of disabled people in society and to redistribute power to those with disabilities. Those in the neurodiversity community extend the social model of disability to account for such weaknesses:

> "According to the social model of disability, society should ensure that all individuals with neurological or physical differences **can be independent and equal in society, with choice and control over their own lives** [emphasis added]. This **may also involve medical intervention to assist** [emphasis added] with what may be perceived as harmful to the individual. Under the social model, **accounts of lived experience are essential** [emphasis added] as they are the best guide for researchers on barriers to independence and equality." [9, p. 5]

2.2. Language Matters

The American Psychological Association APA, [17] provides a guideline for writing about disability in research distinguishing between person-first and identity-first language. Person-first language emphasizes the person before the disability (e.g., person with a disability) while identity-first language emphasizes the disability (e.g., disabled person). According to APA, both language usage are "designed to respect disabled persons; both are fine choices overall." In our work, we use a mix of person-first and identity-first language depending on the preference of the individual or particular community. For example, the autistic community prefers identity-first language [10].

2.3. Intersectionality of Disability with Other Marginalized Social Identities

There is limited understanding of the ways in which disability manifests in marginalized social groups (e.g., people of color, women, queer people, and people with lower socioeconomic status, English as second language in the U.S.). As such, we include intersectionality in our examination of ableist systems [18] as disabled marginalized social groups experience the multiple discrimintation [19], [20]. For example, students of color tend to be overrepresented as disabled in special education [21] where they were "labeled in "soft" disability categories such as emotionally disrubed, ADHD, and, historically, "mental retardation"" [22, p. 107]. This overrepresentation of students of color as disabled perpetuated racial segregation in public schools post *Brown v. Board of Education* [22]–[24]. Therefore, ableism has been used in education as a tool to perpetuate racism.

Further, resources available for people with disabilities are inequitably distributed. For example, the diagnosis process can be a challenge and a barrier for marginalized groups such as women and people of color. Namely, AFAB (assigned female at birth) people and people of color face discrimination by not being believed or taken seriously by medical and pyschological professionals [21]. Another example includes autistic diagnosis rates are lower in people of color and women than in white men despite a lack of evidence suggesting any demographic dependence of occurrence [20], [25], [26]. Further, Ben-Moshe and Magaña point out the book *The Autism Matrix* implies autistic "white children have been historically overrepresented, giving them more access to resources" [22, p. 112]. Thus, it is important to consider the intersectionality of marginalized identities with disability that may further limit participation in engineering.

3. History of Disability and Neurodivergence in Higher Education

3.1. U.S. Education Policies

The history of disability rights in U.S. education systems started with the Rehabilitation Act Section 504 of 1973 [27]. In this act, postsecondary institutions were mandated to "open their doors to students with disabilities and to provide them equal access to an education including support services" [5, p. 30]. The civil rights of students with disabilities were expanded and clarified through the Education for All Handicaped Children Act EHA, [28]. Through this act, educational institutions had to meet the needs of individuals (e.g., accommodate) and improve educational results for students with disabilities through special education, early intervention, and other related services. This law was reauthorized in 2004 as the Individuals with Disabilities Education Act IDEA, [29]. Prior to these acts, students with disabilities were often "denied access to education and opportunities to learn" [30]. Since this act was legislated, educational environments have improved for students with disabilities making education more accessible. The U.S. Department of Education has reported progress for participation of students with disabilities.

Although civil rights of disabled students improved through legislature, educational institution structures still limit disabled students from participating in learning. Barriers begin in K-12, U.S. public school settings where students with disabilities tend to be "othered" by their peers when they receive accommodations for their disabilities [31], especial disabled students with other marginalized social identities (e.g., race). Other barriers include but are not limited to inaccessible campus designs (e.g., facilities, labs, buildings), lack of support for transitioning into adulthood [32], and low self-advocacy skills. Policies such as the Family Education Rights and Privacy Act FERPA, [33] serve as a barrier to receive accommodations. The purpose of FERPA is to protect students' privacy and is an all around good policy. However, higher education institutions require students to disclose their disability status to the institution in order to receive formal learning accommodations. For some students, disclosing a disability status may be a challenge in itself due to inability to self-advocate [34], [35], not having a diagnosis [21], stigma [12], [36], [37], or people not believing they have a disability e.g., invisible disability, [38].

3.2. Disability and Neurodivergence in Engineering Education Research

In general, students with disabilities or neurodivergence are reported around 11% representation at higher education, 4-year institutions [39]. However, representation of disability and neurodivergence in engineering education is proportionately lower as shown in both a large, first-year engineering course approximately 5% of the students surveyed, [40] and the College of Engineering at [redacted for review] approximately 3% engineering students reported identifying with a disability, [41]. Published work on disability and neurodiversity in engineering education is limited. Fortunately, such research is beginning to gain intereset in the engineering education research field. Particularly, researchers have studied how to increase awareness in engineering students in designing for disability [42]. Other researchers have started to explore neurodiversity in engineering including the stigma of mental illness [36], [43] and experiences of students with ADHD [44]–[48].

4. Method

We conducted a preliminary qualitative study that presents the narratives of two engineering students (Autumn, graduate student and Brady, undergraduate student) and their experiences in engineering education with disability and neurodiversity. This work preludes to a collaborative autoethnography study where we will explore our narratives as disabled and neurodivergent people in engineering education.

4.1 Reflexivity of the Research Team (Positionalities)

The narrative and collaborative approach to this research puts additional importance on considering our roles as a research team in the writing and discussion of the narrative experiences expressed in this paper. The sensitive topic of this research, on ableism and disability and neurodiversity in engineering, is not widely accepted in the engineering community. This positionality statement is framed to be open about the experiences we choose to share in this narrative, the processes taken in writing this work, and our past experiences that may provide context for our readers.

The authors of this paper have backgrounds in engineering and experiences with seeking accommodations in undergraduate engineering. Although some of the authors and researchers in this work identify as neurodivergent, disabled, or have close family members who are neurodivergent or disabled, not all authors identify as having predominantly neurodivergent characteristics. We each share a passion for decentering the societal norms for ability particularly around cognitive functioning.

Collaboratively, we bring expertise in identity-based motivation, career goals, wellbeing, neurodiversity, particularly autism and ADHD. Two authors contribute self-identified descriptions of their experiences in undergraduate engineering as a neurodivergent students, while the additional authors provide context and discussions connected to literature around the topics the narratives address.

4.2 Participant and Data Collection

Participants in this paper are the first and second authors who share their experiences as neurodivergent students in undergraduate engineering. Data collection occurred in the writing process of this paper. The remaining authors developed written prompts, and asked the undergraduate researchers to write in their thoughts as a response to the prompts. Some edits were made for clarity, but otherwise, the data is presented in the form of self-expressed narratives.

4.3 Analysis

Analysis was a thematic approach drawing heavily from literature in accommodations in higher education, critical disability theory, and mental health and neurodiversity in engineering education. Analysis occurred as open discussions led by Marissa Tsugawa, the lead researcher. These discussions pulled key themes from the narratives and connected them to literature. Each author individually read through the responses, provided questions for clarity, and indicated key themes to include. The responses were combined and presented after the student narratives as a continued discussion. Writers of the narratives were not present for this initial discussion, but brought input with questions and comments to the discussion.

5. Engineering Student Narratives

The narratives presented below are from the perspective of each participating author of this paper. They each use the first person in their narratives.

5.1 Autumn's Narrative with Disability in Engineering

The following includes the Autumn's narrative around disability in engineering education. Autumn prefers to use person-first language in describing her disability (e.g., person with a disability). Further, Autumn recently graduated with her Bachelor's and Master's degrees in computer science and engineering at the University of Nevada, Reno, a large, public university in the west. This institution has a Disability Resource Center (DRC) that works closely with disabled and neurodivergent students and faculty. The active Neurodiversity Alliance group associated with the DRC at this institution advocates and raises awareness of disability and neurodivergence in higher education on campus. This group along with faculty actively working with the Neurodiversity Alliance strives to make the campus a more accessible place for every student.

Describe your undergraduate education experience in engineering with a disability.

As a person with a disability, my education experience in engineering has been unique from my other peers. A lot of engineering, besides programming, requires hands-on manipulation. This made labs like Physics and Computer Engineering extremely difficult for me. My disability causes my body to shake uncontrollably. I had to handle wires, chips, and running physics experiments which were beyond my capabilities. These challenges did not stop my desire to earn my Bachelor's degree in computer science. I had to find other ways to perform these tasks. My alternative method was to have an aide. The aide dealt with the physical aspects of the lab while following my strict instruction. This allowed me to learn the material like everyone else, just with a substitute pair of hands. **My experience has a lot of minor substitutions, but not to adjust the education. They just helped me display my knowledge like every other student.**

The two constant substitutions in my education experience in engineering are using my laptop to complete assignments and getting extra time on exams. I use computers every day. They are my hands whenever I need to write. Not any computer will do, though. I must have an additional part on the keyboard for me to use it properly. This part is called a keyguard. The keyguard is just a plexiglass cover that allows me to get accurate keystrokes. My laptop has a custom one that enables me to do work anywhere. This work may be recording audio of a lecture or typing up my homework assignment. I also use my laptop to complete my exams. Because of my tremors, it usually takes me longer to complete a task than others. One substitution that helps me combat this is getting extra time on exams. I usually take my exams at my university's Disability Resource Center. They give me a separate room so I can take my time completing the exam. My brain thinks faster than my hands can type. [Thus], the spare time is for me to get all my thoughts down.

Overall, describe your experience with finding and receiving accommodations (e.g., from a disability resource center, DRC). What was beneficial about the accommodations? What challenges did you have with receiving accommodations?

It was easy for me to find and receive accommodations from my Disability Resource Center (DRC). I believe this is because of my high school staff. **My high school IEP [individual education program] director arranged a meeting with my college's DRC before graduating.** This meeting gave me knowledge of what I needed to do for accommodations. I was ready to go when I started class the following fall. I was able to get all the minor substitutions I needed for the class immediately. This was very beneficial because my knowledge could shine regardless of my physical capabilities. My accommodations were not the only thing that was beneficial to me. The DRC staff were beneficial as well. My DRC counselor was always available when I needed some help. The help could be getting a note-taker for a class or fixing something on my laptop. It wasn't just my counselor that continuously wanted to help. Everyone at my school's DRC gave a lending hand when I needed it. This willingness to help eliminated the majority of the challenges with receiving accommodations. The only issue I had was a professor not wanting to give the DRC their exams. My counselor quicking resolved this issue before my first quiz was even scheduled. My accommodations and DRC staff assisted me in achieving my goals. I don't know where I would be without them.

What was your experience with diagnoses and access to diagnoses?

I was a baby when I was first diagnosed with my disability. My family noticed something was different when I wasn't meeting some of the milestones most babies meet. A diagnosis may have been challenging initially, but now everyone around me knows I have a disability. Because of this, I had an easy experience with diagnoses and access to diagnoses. I have always known that I am a person with a disability. **My disability is visible, so everyone can quickly see that I'm unique.** Doctors can easily write a diagnosis if a proof is needed for any reason. I guess I am lucky in this sense. An early diagnosis means I can efficiently give evidence of a small part of who I am.

What is your perspective of researchers on disability and neurodiversity? What direction do you think researchers need to go in understanding disability and neurodive?

Neurodiversity is a relatively new area of research. **Not everyone experiences disabilities in the same way.** This means researchers must hear from multiple different people with different disabilities. These interviews will provide similarities and differences on how individuals with disabilites handle everyday life. Researchers can then use this information to improve areas for everyone, not just one group. **This may be changing teaching methods to learn how that makes sense to their brain—or developing technology that can increase individuals' level of independence.** These research discoveries could not just benefit people with disabilities. **They can also improve the way of life for everyone.**

5.2 Brady's Narrative with Neurodivergence in Engineering

The following includes the Brady's narrative around neurodivergence in engineering education. Brady is an industrial engineering undergraduate student at Iron Range Engineering, a small upper division engineering program. In this program students earn course credits for design experiences through industry projects and co-ops. This co-op based learning, upper-division engineering program incorporates elements of universal design for learning to support a wide variety of student backgrounds and needs [49]. Specifically Iron Range Engineering fosters neurodivergent student experiences through multiple course material formats (asynchronous materials: videos, notes and texts). Assessments are done through verbal exams, allowing flexibility for follow-up questions and opportunities for multiple forms of expression. The program curriculum includes workshops and provides additional resources for how to navigate the workplace and learning when coping with mental health or wellbeing concerns.

Students in Iron Range Engineering have weekly meetings with a mentor, staff with engineering degrees, and the program keeps an inclusive culture for informal mentorship [50]. Although 30% of students identify as having a disability, students rarely apply for accommodations or bring letters of accommodations to instructors. These conversations occur informally and personalizations are made as part of an open discussion.

Describe your undergraduate education experience in engineering with neurodivergence.

My experience in engineering education has largely been perceived outside the context of neurodivergence. Only now, at 23 years old, do I have the information to reflect on my education through the lens of neurodivergence. Throughout my years leading into engineering, I struggled with executive functioning and anxiety. However, my perception at the time was that everyone dealt with the issues I faced. I wasn't special, save the strong intellectual skills that carried me to college without the need for studying. I learned how to maintain an appearance to meet the expectations put upon me socially and in the classroom. The truth is, I wasn't trying very hard.

I started my post-secondary education in community college, a decision made by default as I applied to only a few schools. The application process was daunting to me, and of little interest after the third or fourth application. It was not urgent, the prompts were only interesting a few times, and I reassured myself that my above-average GPA, high SAT score, and extracurriculars would lead to acceptance into at least one of the schools I wanted to attend. However, my options were slowly retracted, either by: a rejection letter; circumstance with my parents after an impulsive and poor decision on my part; or discovering that I wouldn't fit in as my personal views were in flux. So, by default, I went to the community college I had already technically attended through dual-enrollment courses in high school. The first college final I took was Calculus 2; I was terribly unprepared for that test. The timed, written test in a silent room was a jarring entry into engineering. I earned a C in that class and told myself I would learn from that mistake. However, that class remained one of the few challenging courses I would take for the next two years. I fell back into old habits very quickly. I was left to drift through my coursework, with little to no interaction with the college faculty other than my professors; I had no reason to. **As I went from class to class, I was a successful student in the eyes of most including the college–everyone except my future self.**

The challenge would come as I transitioned into a non-traditional engineering program recruiting students from community colleges. I lived away from home for the first time, spending 6 months with strangers. I was administered tests orally and given engineering projects to work on. I remained a procrastinator, getting just enough work done in enough time to remain fairly successful. I was kept accountable by those in the program with me, pushing me to remain motivated. But, yet again, I failed to be motivated toward the future. I submitted fewer applications to internship and co-op opportunities than was expected and necessary, whether by lack of perceived preparedness or by lack of urgency.

My wake-up call came in Fall 2021. I was now on my own, taking classes virtually. I was back at home, supported by my parents. I failed to remain motivated without the support structure I had unconsciously come to rely on. I didn't finish required coursework over the summer of 2021 and told myself and those around me I could complete it in the Fall. I never did, as I had taken a co-op opportunity. I took the opportunity because I felt that I needed to gain experience, but my poor time management, the isolation and lack of accountability, and the increase in hours took me past my breaking point. The tasks seemed manageable, and the other student living with me managed to keep taking classes, despite the increase in hours.

Something was different about me. I knew that I regularly took longer on assignments than my peers. I knew that I was easily distracted unless it was of interest or urgent. But, I never connected the dots until I completely stepped away from my education. I had always been told that I was made this way. I never considered that I might be different. But, now I had truly failed: not to reach my potential or plan ahead. I had failed where others could try harder and succeed. The difficulties I had with engineering weren't with the content or the structure of the program. The difficulties I faced were from my ability to function as two people: a working adult and a student. **The way that I functioned didn't facilitate that many responsibilities and complexities now that the built-in educational supports were gone and I had added the responsibilities of work. My default method of functioning was different.**

What was your experience with diagnoses and access to diagnoses?

My experience with my ADHD and Generalized Anxiety Disorder diagnosis was a fortunate one. I'm blessed to have a family that is supportive and could provide me with the resources to see a psychologist. The largest barrier to my diagnosis was time. At 22, about a year ago, I had progressed into adulthood, college, and living on my own before I began to see issues with the way I functioned. The emotional weight of fully stopping my education was what made me want to get assessed. However, my parents were hesitant. They held the same belief that I had been told for 20+ years, "It's just how I was made."

The diagnosis process was simple. I and my parents filled out surveys beforehand; I spent a full day with an examiner, completed lots of tests, and eventually received a diagnosis of ADHD and Generalized Anxiety Disorder. The diagnosis came as a surprise. I had suspected either one or the other, with the concept of comorbidities still completely foreign to me. **The hardest part of the diagnosis was that I had received an answer and not a solution.** While others had time to learn how to adjust before entering adulthood, I was attempting to undo literal decades of habit building. I felt that I had this amazing answer to many of the questions I had asked myself over the years. But, to everyone else, I was still just me, the same as I had ever been. This cognitive dissonance caused me to question if I belonged in the neurodivergent community. It wasn't until I had the vocabulary of that community and consciously recognized myself beginning to "mask" less in front of an educational staff member that my sense of how ingrained my attempts were to conform to my perception of "normal."

Overall, describe your experience with finding and receiving accommodations (e.g., from a disability resource center, DRC). What was beneficial about the accommodations? What challenges did you have with receiving accommodations?

I again reached a difficult decision this past fall as I began classes in my program once again. I decided not to apply for accommodations. In hindsight, and likely the opinion of others, this was a mistake. I had convinced myself with the help of those close to me that the world would not provide accommodations to me, and that it was my responsibility to conform to the world. **I feared what would happen if I put supports in place that could once again be taken away.** However, I'm now seeking official accommodations. In the past, I've benefited from very positive working relationships with teachers, professors, and others. But, a helpful extension or additional time only afforded me a treatment to my symptoms, not the root cause. With the help of an education faculty member I've come to the realization that if a company isn't willing to accommodate me so that I can reach my highest potential, I have no desire to work for that company.

What is your perspective of researchers on disability and neurodiversity?What direction do you think researchers need to go in understanding disability and neurodiversity?

Having only recently entered the research field, my view of researchers on disability and neurodiversity is fairly fresh. Although, I can reflect on perception through the actions I took following my diagnosis. My first instinct wasn't to look through the DSM-5, or at current research. I went to Tiktok. I felt alone, isolated in this newfound understanding of my tendencies and functioning, and I looked to others to confirm my experience. I wanted to evade the immediate imposter syndrome of a diagnosis later in life. From that, I can only reflect on how and where research is presented and focused. If the goal of the research is to learn more about the experiences of those in the neurodivergent community, then researchers must seek out the community. **From my personal experience, I think researchers would find better results if their studies incorporated the intense emotional experiences of those who are labeled as different, both positively and negatively.** Even from my short time in a parasocial relationship with the community on social media, having few neurodivergent friends, I can confidently say that I believe the community is willing to help those in academic power help us in good faith.

5.3 Key Themes and Connection to Literature

Obstacles to Diagnoses

"My disability is visible, so everyone can quickly see that I'm unique." – Autumn

"Something was different about me. I knew that I regularly took longer on assignments than my peers. I knew that I was easily distracted unless it was of interest or urgent." – Brady

Disability is considered the largest marginalized group in the U.S. because any person has the potential to be disabled [3]. Disability can occur from birth or due to a traumatic event including those disabilities that are temporary (e.g., broken bone, anxiety from workload). However, disability is experience at an individual level as shown from the two authors' narratives presented in this work. Autumn was diagnosed with a disability as a baby from not meeting development milestones. She also highlighted that her disability is visible, so people around her are able to see that she is unique which attributes to a straightforward process to receive accommodations. Particularly, she described how her high school helped connect her with the university's Disability Resource Center and worked with her to receive accommodations and learn self-advocacy. Over her life, Autumn has recognized her capabilities and views receiving accommodations in education as enhancing her learning experience and giving her the opportunity to express her knowledge and competence in engineering.

In contrast, Brady's experiences highlight the difficulties students may face with seeking diagnoses for invisible disabilities, particularly for those who have excelled academically in high school. Even with a diagnosis, making the decision to seek accomodations and the self-discovery needed to identify accomodations and methods of support served as an obstacle that the cost and timeline of higher education do not support. Further, students who do not realize they have an invisible disability and begin to struggle in college are more likely to drop out [32], [51], especially those who do not develop a sense of belonging [52], [53]. Brady also highlighted a tension he felt with receiving a diagnosis and moving forward with officially asking for accommodations for his newfound neurodivergent identity: "the hardest part of the diagnosis was that I had received an answer and not a solution."

Access to Engineering Degrees

With the disability acts in the U.S., higher education became more accessible for students with disabilities to participate in obtaining degrees [5], [30]. Particularly, disability services, such as those from Disability Resource Centers (DRC), are able to provide accommodations to students with disabilities for learning equity [54]. Although institutions are mandated by law to provide accommodations, students must self identify with having a disability that needs accommodations for learning. The authors of this paper described two different experiences for accessing their engineering education based on the available disability support services and systems at their institutions and their particular limitations.

Autumn stated that the major limitation from her disability is physical. As such, Autumn needed accommodations that would aide her physical capability. She indicated having success with asking for and receiving accommodations from the DRC. The success here is attributed to those social connections between high school support and the college DRC. Prior to entering college, Autumn and her high school staff talked to the DRC together about accommodations, which was an opportunity for Autumn to learn self-advocacy. The accommodations that she needed allowed her to be successful in expressing the her knowledge and competency in engineering.

In contrast, Brady received a later in life diagnosis with ADHD and indicated that he did not have the tools to address his needs. Particular to some types of neurodivergence (e.g., ADHD), executive dysfunction interfers with a neurodivergent students' capability to physically act on their thoughts or even have difficulties with making decisions [55]. For Brady, the decision to seek accommodations through his DRC was approached with uncertainty because of how accommodating faculty are already at his institution. However, Brockelman [56] indicates that strategies, many of which his institution utilizes, are not effective for students with psychiatric disabilities. Burgstahler [57] highlights that mentoring and social supports are key elements for facilitating students in entering STEM fields and in completing STEM degrees [57]. Even in a program with strong mentoring, social support, and elements of the universal design for learning, the struggles faced by those with disabilities, and specifically neurodivergent individuals, can be obstacles to finishing a degree. With our existing supports in academia being shown to be ineffective and not frequently utilized for neurodivergent populations [56], a clear need for systemic change is indicated.

Representation in Academia and Research for Neurodiversity and Disabilities

“Not everyone experiences disabilities in the same way.” –Autumn.

As highlighted by Autumn, disability is experienced at an individiaul level or is unique to each person. When disability is visible, people can see that in a person. However, invisible disabilities are easier to hide or may not be easy to convey to others e.g., disability must be disclosed and believed, [54]. Visible and invisible disability representation is important in higher education to demonstrate to disabled students that they can pursue their career interests and achieve college degrees [58]. Further, representation of disability in higher education can increase awareness of disability and neurodiversity to those who can make change in systems. In engineering specifically, more engineers with disabilities will bring their life experiences to make more accessible engineering designs, especially those with intersecting marginalized identities. Brady’s call for change in academic research highlights an important issue on equity and representation in academia. With 13% of undergraduate students reporting disabilities and only 4% of academics identifying as having a disability, representation or open discussion of disabilities is lacking in academia and research [58]. Part of this disproportionate representation is due to access to diagnosis [21] but also the decision for individuals to disclose their diagnosis [54], [58]. Brown and Leigh [58] discuss obstacles to disclosure based on biases in academia; however, Brady brings up an additional consideration: “I feared what would happen if I put supports in place that could once again be taken away.”

6. Implications and Conclusions

The themes highlighted in Autumn’s and Brady’s narratives connect to the need for systemic change in higher education, particularly in three areas: accessible pedagogy, student voices in research, and paradigm shifts in how we view and discuss neurodiversity.

6.1 Need to Include Neurodivergent and Students with Disabilities Voices in Developing Accessible Pedagogy: Universal Design for Learning in Higher Education

In addition to structural levels, traditional pedagogy that is still widely practiced in engineering education limits neurodivergent students’ access to learning. For example, engineering educators commonly require students to submit written homework to demonstrate understanding, practice solving engineering problems, and receive grades. However, accessible pedagogical practices, such as the Universal Design for Learning [15], [59], [60], recommend allowing students to have autonomy in the way they demonstrate their understanding e.g., verbally explaining their thought processes for solving a problem, [61]. This example highlights the limitations of traditional homework models and assessment techniques that work for those who are capable.

Autumn states this well in her narrative: their ability to express knowledge is there, but is hindered by existing structures and current curriculum formats, such as physical labs. A universal design for learning would switch the focus from identifying appropriate accommodations, to the system being inclusive of all individuals. The current structure puts the demand on the individual to seek appropriate accommodations. In Autumn’s examples, the communication between high school support and college DRC helped this transition. Brady’s example highlights that when diagnoses are not present or do not happen early on, identifying appropropriate accommodations is an obstacle to gaining and demonstrating knowledge.

6.2 Need to Include Disabled and Neurodivergent Engineering Student Voices in Research

Past research have called for the inclusion of disabled and neurodivergent voices in research [34], [62]–[64]. By including disabled and neurodivergent voices in the research process, researchers can capture the range of experiences and meanings from their perspectives. Particularly in engineering education, researchers can begin to identify and target the learning needs of disabled and neurodivergent students through their own terms. For example, Gillespie-Lynch and colleagues [34] included autistic and other disabled college students in their research to identify the specific support needs to be successful in higher education such as the opportunity to socialize with other autistic students. As such including such voices in research can highlight disabled and neurodivergent experiences in their own terms.

6.3 Need for a Paradigm Shift to Understand Disability and Neurodiversity in Engineering Education

Additionally, including disabled and neurodivergent voices in research can guide researchers to approach such topics with anti-deficit frameworks. For example, researchers can learn the strengths and weaknesses of having a disability or neurodivergence in engineering education. Approaching disability and neurodivergence with a strengths/weakness lens highlights a student's successes and identifies challenges that may be addressed through systemic change (e.g., implementing universal design for learning, deconstructing policy). By listening to disabled and neurodivergent voices, researchers can begin to understand the different aspects of being disabled and neurodivergent aside from the meanings defined by diagnosis criteria that may perpetuate deficit frameworks e.g., DSM-V, [65].

Research approaches that can uplift disabled and neurodivergent voices include using participatory action research designs, cripistemology, and indigenous paradigms. Participatory action research is a research methodology and method that is "based on reflection, data collection, and action" [66, p. 854]. Reflection and action in this methodology are linked together and is influenced by context. This methodology also empowers participants by giving them some control over their own lives. For example, researchers can guide student participants in engineering education to identify their strengths and weaknesses as engineers. By guiding participants, they will learn how to reflect and self-identify their strengths and weaknesses to navigate how those characteristics influence their education and professional development. Participatory action research has been, but is not yet widely used in engineering education research e.g., [67]–[70].

Another alternative approach for researchers studying disability and neurodivergence includes a paradigm shift to cripistemology [71] and indigenous paradigms [72], [73]. Cripistemology (crip theory) challenges the disabled/non-disabled binary by instead exposing compulsory able-bodineses and able-mindedneses in all contexts [71]. In other words, a cripistemology allows researchers to identify what is deemed as 'normal' and conceptualize disability as fluid. Indigenous people assess disability and neurodivergence "by the degree to which a specific condition affects an individual's ability to participate in social and cultural obligations" [74, p. 6]. Particularly, all people in Indigenous communities are considered to be an equal and contributing member of the community regardless of their ability [74], [75]. Further, Indigenous people believe in and embrace the idea of multiple realities and truths. In the context of disability and neurodivergence, that means there is no conflict between Native healing and conventional medicine [75] which accounts for the critiques and weaknesses of the social model of disability. As such, Indigenous paradigms can enhance our understanding of disability and neurodivergence and lead engineering education researchers to understand how disabled and neurodivergent engineers uniquely contribute to the engineering community.

7. Summary

Our paper examines the educational structures and systems that limit the participation of disabled and neurodivergent students in engineering education. In the U.S., educational policies and structures meant to support disabled and neurodivergent students either replaced racist segregation or served as additional barriers for disabled students to access education. Research in engineering education are starting to explore neurodivergent student experiences and the stigma of mental illness. Our work adds to this discourse by sharing narratives. Particularly, two of the authors shared their personal narratives of having a disability and being neurodivergent in engineering education which demonstrated different experiences based on the level visibility of the disability and when they were diagnosed. Implications from this work include involvement of disabled and neurodivergent voices in research and pedagogical design and utilizing methodologies and research paradigms that center participants and lead to action and reflection.

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