Qualitative Analysis of Neurodivergent Students' Experience in Engineering

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Abstract

While students with learning differences enter college in rising numbers, they have not seen tangible improvement in their post-secondary education and career outcomes. Across engineering programs, neurodivergent students tend to be under-represented, under-performing, and under-employed, despite their engineering-friendly traits. Whilst helpful, university accommodations, such as note-taking, speech-to-text, exam-time extension, etc., do not address their deficiency in higher-level cognitive skills (e.g., planning, time management, communication), except at a handful of colleges that have special programs offering coaching and social integration for neurodivergent students.

This paper presented a thematic study based on interviews conducted on nine neurodivergent students enrolled in engineering and physics at a four-year university on the West Coast. The paper summarized the challenges they have experienced and the strengths they possess through their lived experiences in teamwork and other learning contexts. The results could identify gaps and inform inclusive teaching strategies, especially in areas involving higher-level cognitive skills that tend to be overlooked by existing accommodations and pedagogical practices. Reframing their educational experience in both challenges and strengths could combat the stigma associated with deficit-based models. Moreover, by looking into the duality between challenges and strengths, the results of this study could help students identify the conditions that turn their challenges into strengths and vice versa. Such self-awareness skill is fundamental to developing self-efficacy, leveraging one's strengths, and seeking the help that one needs via self-advocacy.

Introduction

Although students with neurodivergent conditions (e.g., autism, dyslexia, and ADHD) possess engineering-friendly traits (e.g., pattern recognition, reasoning, Chrysochoou et al. 2022), they experience lower graduation and employment rates compared to their neurotypical counterparts (Clouder et al. 2020, Hillier et al. 2018). The barriers contributing to their lower education outcomes can occur at the personal (self-control, independent living skills, etc.) and structural (accommodation, hiring process) levels. Neurodiversity illiteracy of faculty presents another hurdle for student success and persistence in engineering, while some students are reluctant to seek help or request accommodations for fear of stigma or being "outed." Existing university accommodations for neurodivergent learners primarily consist of supports such as note-taking assistance, extended exam time, and modified testing environments, which remain among the most commonly implemented provisions in higher education disability services (Gelbar, N. W., Smith, I., & Reichow, B., 2014). While helpful they do not fully address students' difficulty in higher-level skills (e.g., information processing, planning, prioritization, communication). Special programs offering coaching and social integration for neurodivergent students are distributed unevenly across geography in this country (Nachman et al. (2022).

Literature Review

The narratives from education research and practice tend to focus more on their deficits than their strengths. Notwithstanding the importance of amelioratory knowledge, our study will examine challenges and strengths simultaneously across learning contexts, including teamwork.

Students enjoy better outcomes when they harness their strengths while addressing their limitations than solely focusing on their limitations (Wehmeyer, & Schalock, 2001). Moreover, understanding how a neurodivergent trait can present a challenge or strength and whether that depends on the context will help to create better intervention and pedagogical practice.

Salvatore et al. (2024) investigated how neurodivergent undergraduate students experience group work in STEM courses through qualitative interviews with 22 participants. They found that individual characteristics (e.g., attention, communication, time management) interacted with group and classroom environments to create either supports or barriers to participation and belonging. Many of the known challenges (e.g., unclear expectations, poor communication, uneven workload distribution, and misalignment in work styles) often disproportionately affected neurodivergent students due to their cognitive and behavioral traits. While students developed strategies (e.g., structured planning, selective communication, and self-advocacy) to navigate group work, these strategies became less effective when group dynamics changed and classroom cultures became competitive, negatively impacting students' sense of belonging. The study concludes that inclusive group work design requires intentional instructional practices (i.e., clear expectations, structured support, flexibility) and fostering an inclusive classroom culture.

Zastudil et al. (2025) conducted a systematic literature review examining research on neurodiversity in computing science education, to identify support needs of neurodivergent students. Their review indicated that strong empirical evidence and guidance for students were presently missing in computer education while suggesting key directions for future work, e.g., studying the impact of active learning, increasing awareness of neurodivergent student experiences, and involving neurodivergent students in the design of educational practices and research. Quigley and Gallagher (2025) interviewed 18 neurodivergent students via a participatory study design illuminating students' lived experiences. They found that students struggled with double masking – not only must they hide their neurodivergence to fit neurotypical norms but also conceal perceived inadequacies when they do not align with stereotypical strengths associated with neurodivergence (e.g., creativity, math skills, hyper focus). They argued that higher education must move beyond superficial inclusion efforts and fundamentally rethink how it defines success, value, and support to encourage equitable participation.

Our study adopts a social-relational lens of disability to examine the interplay between challenges and strengths, drawing on students' lived experiences in teamwork and broader learning contexts. By exploring this interconnection, we refine a strength-based perspective that integrates neurodivergence into learning experience, rather than treating it as exceptional or marginal. Using semi-structured interviews, we aim to expand on the prevailing or often stereotypical strengths by centering students' own accounts. We further situate our findings within educational psychology frameworks to inform future research and the development of evidence-based recommendations and strategies. Finally, we explore how emerging tools, such as generative AI, may support and enhance the capabilities of neurodivergent students.

Student Recruitment

This study aimed to probe the education experiences of neurodiverse students in engineering, using a sample collected at a four-year university in the west coast of the United States. The

university had four ABET-credited engineering programs (civil, mechanical, and computer/electrical engineering). The study recruited participants through the email list of the university's Disability Program and Resource Center (DPRC). Ten students who are registered with DPRC responded to the recruitment email. Nine of them consented and were able to participate in the interviews. A snapshot of their demographic characteristics is provided in Table 1.

Table 1. Learning conditions and other demographic attributes.

Pseudonym	Major	Race	Learning differences	Demographic snapshot
Gabriel♂	Civil Engineering	White	ADHD	Diagnosed at college, transferred from UC
James♂	Computer science	Hispanic/Latino	ADHD	Diagnosed at CC, Transferred to SFSU from CC in 2022
Oliver♂	Mechanical engineering	Two or more races	ADHD	Diagnosed at 2nd Grade
Sophia ♀	Computer engineering	Asian	ADHD	Transferred from CC in 2023, diagnosed in 2025
Theodore ♂	Physics	White	ADHD, ASD, dyslexia, dyscalculia, RSD	B.S. in CS, currently pursuing a B.S. in Physics
Lucas ♂	Mechanical engineering	Asian	ADHD, ASD	Diagnosed at age 10
Phoenix ⚲	Mechanical engineering	Asian	ASD	
Jordan ⚲	Civil Engineering	White	ASD, mild ADHD	Diagnosed during childhood, senior student
Henry ♂	Civil Engineering	White	ADHD and EF	

♂ = male; ♀=female; ⚲=nonbinary; ADHD= attention deficit hyper activity; ASD= autism spectrum disorder; EF= executive functioning; CC = Community College; UC = University of California

All nine interviews were transcribed and anonymized by a licensed contractor. All transcripts were further checked by the research team for accuracy and to ensure that no person-identifying information (e.g., internship, names) was present.

Methods

Semi-structured interviews were employed for this study because it ensured consistency to support the research objectives but also allowed opportunities for discovery. The interview protocol was developed in an iterative process. First, draft questions were informed by the key elements from relevant literature. Next, two researchers refined those questions through discussions and peer-reviews to improve clarity, relevance, and appropriateness for the target population. Lastly, the draft protocol was presented to a neurodivergent student for her feedback, resulting in minor but necessary edits to the protocol.

Desensitized transcripts were used to perform thematic analysis in a hybrid process involving two faculty researchers -- who led the analysis—and moderate assistance from ChatGPT. First, the researchers identified the general themes, mirroring the protocol of the semi-structured interviews, and created prompts based on those themes, including:

- What challenges has the student experienced?
- What strengths does the student possess?
- How did the student experience engineering teamwork with peers and interactions with professors?
- How did the student perceive AI tools like ChatGPT?
- What strategies have helped them the most that they would recommend for inclusive teaching/learning?

Those prompt questions were used to guide ChatGPT as a coding framework to extract information from the transcripts. An additional prompt was used requiring ChatGPT to provide quotes from the transcript to support each claim that it made. The ChatGPT responses were cross-validated by the two researchers through discussions and reflection memos, removing spurious outputs when hallucinated and adding new findings where missed.

This hybrid method could expedite the traditional method if a few contingencies are met. First, the researchers review each transcript several times, to generate well-informed, prompt questions. Second, only anonymized transcripts are used when interacting with open-source large language models like ChatGPT, to protect human subjects in qualitative research. Lastly, each output made by ChatGPT is triangulated by researchers. Triangulation is critical for interpreting meanings within contexts because ChatGPT can over-generalize and miss the nuances in a subject matter (Fiesler, & Garrett, 2023). For instance, an interviewee expressed difficulty with self-advocacy (ask for what one needs) during the interview and was labeled as such by ChatGPT, but the explanation that he provided later showed that it was self-promotion (highlight one's achievement to gain recognition) with which he struggled. Such cases were detected through triangulation and corrected in this study.

Thematic Analysis and Results

Through an iterative process of coding and cross-validating, we reached consensus on several emerging themes that could inform intervention strategies to improve education outcomes for neurodiverse students within or outside of teamwork contexts.

Theme 1: The top challenges reported by engineering/physics students in our sample include chunking information, imposter syndrome, anxiety, time management, and attention/focus. These challenges are shared across different learning conditions.

The analysis revealed that students across learning differences shared several key challenges, as shown in Figure 1. At least half of the students whom we interviewed reported difficulty with attention and focus, time management and planning, general or social anxiety, imposter syndrome, sensory sensitivity/overload (including processing information), and short-term or working memory. Most of these challenges echoed prior findings (Salvatore et al. 2024). Three of the four students who have ASD expressed challenges with social communication (e.g., small

talk stress), as expected because autism is a neurodevelopmental condition that affects a person's ability to perceive their environment and interact with others.

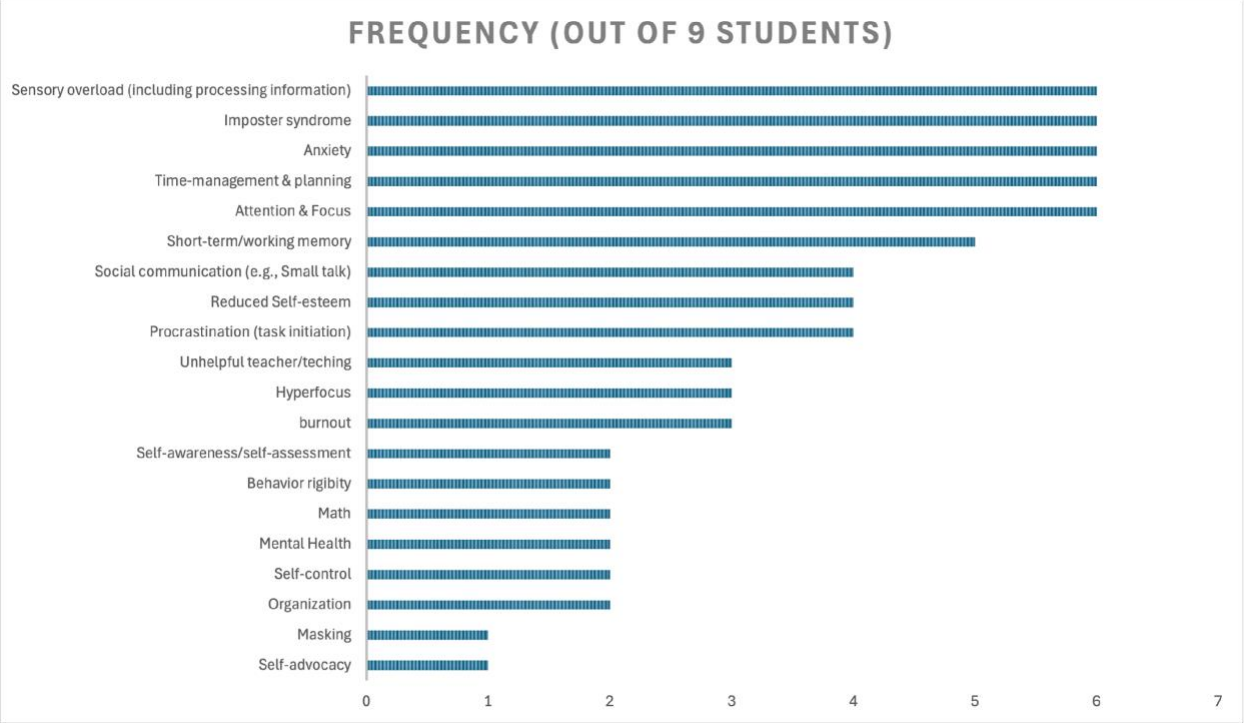


Figure 1. Frequency of Self-Reported Challenges Among Neurodivergent Engineering Students**.**

Theme 2: Neurodivergent trait like special interests provides a source of relaxation and social belonging. Traits that are viewed negatively like rigidity and fixation can produce positive outcomes during teamwork, whereas positive traits (e.g., self-awareness) may become an impediment during teamwork.

For example, James demonstrated a high level of self-awareness during the interview by being keenly aware of and articulating his challenges and coping strategies (public space and ambient music to help with focus). However, when not supported by self-assessment, he wrongfully believed that other teammates were more knowledgeable and capable and struggled with contributing ideas and speaking up for himself during group discussions. Such negative experiences hurt his self-esteem, another challenge that he identified. A similar pattern was reported by Theodore, who expressed that his attention to detail worked as a double-edged sword depending on the contexts (e.g., open-ended problem solving or homework problems).

> Theodore*: "Attention to details, mm, I see the details there. If I'm doing homework, the attention to details falls off. If I'm doing a project, the attention to details goes through the roof."*

Similarly, Phoenix recognized that their challenge with rigidity and fixation on routine could have positive effect on teamwork, echoing the work by Salvatores et al. (2024) who argued that the need for routine could promote organization/planning while creating hurdles to task switching.

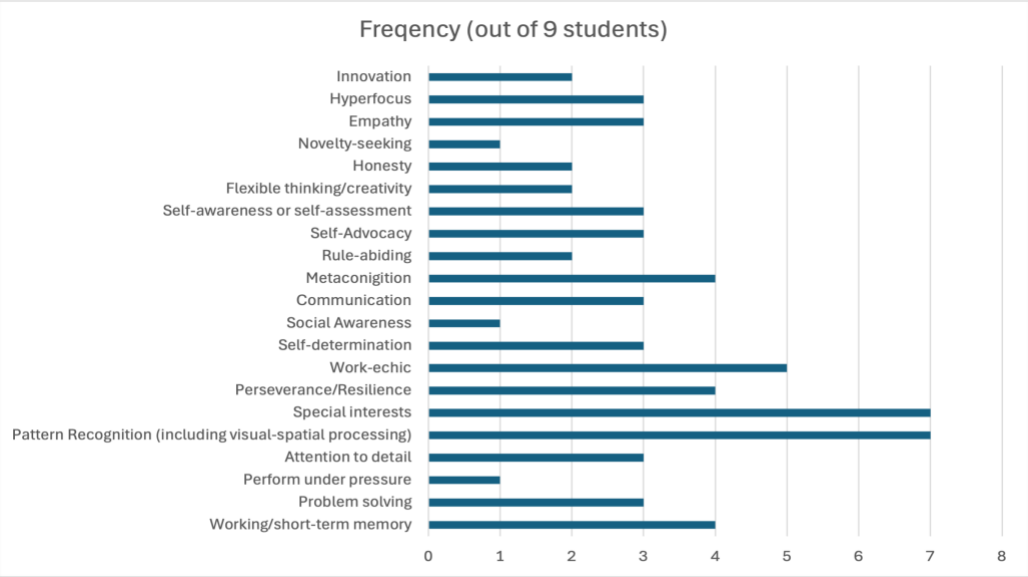
> Phoenix*: "I mean, kind of I feel like I'm always repeating myself in the sense of my challenges end up also being certain strengths in certain times…Like, okay, I really want it this way or getting it on time, for us at the same time. I'm able to kind of push my groupmates to work on it I think more than they would have if I wasn't pushing them."*

Figure 2 summarized the frequency of strengths across the nine students. Many of them enjoyed special interests ranging from technology (Sophia), Marvel movies (Lucas), service dog training (Phoenix), and a specific course (Oliver). Theodore exhibited a very broad interest in learning. These special interests provided students a source of relaxation and social belonging, which could lead to higher self-esteem, emotional regulation, and quality of life (Courchesne et al. 2020). Special interests[1] can be used as external reinforcement (Charlop-Christy and Haymes, 1998, as cited in Courchesne et al. 2020) or to develop learning materials (Ostrolenk et al. 2017), reverberated by a quote from Jordan:

"*Weaponize our special interests. If you can attach—this often requires knowing the person—but if you can attach a concept you're trying to teach to a neurodivergent person's special interest, it is much easier to learn."*

and Lucas: *"*I'm a true and passionate Marvel fan… I know all the characters." "I'm actually thinking of starting a club… to showcase everything we know about Marvel and the MCU."

The perseverance and self-determination that were forged as they coped with their learning differences was also deeply touching and consistent with the self-determination theory (SDT) (Ryan and Deci 2020).



[1] On a side note, a case study by Courchesne et al. (2020) suggested that any attempt to use special interests to improve learning must consider the individual characteristics. They also warned that expecting students with autism to quickly turn their strengths into greater academic performance may contribute to anxiety.

Figure 2. Frequency of Self-Identified Strengths Among Neurodivergent Engineering Students.

Theme 3: Misaligned self-assessment and unrealistic goal setting foreshadow poor self-esteem and other mental health challenges.

While self-awareness enables students to know who they are (e.g., values, traits, and behaviors), self-assessment allows them to evaluate how they are performing (Carden, Jones and Passmore (2021); Eby, D. W. et al 2001). When students measure themselves up to unrealistically high standards, they are prone to frustration and low self-esteem, the latter of which negatively impacts mental health (Orth and Robins, 2022).

> Sophia*: "But I think I definitely treat it as like an all-or-nothing kind of, like, mindset, where it's like, oh, if I can't live up to that standard, then is this really engineering, right?"*
>
> Oliver*: "I keep a very—I keep—I hold myself to a high standard, and I've had to work on having—holding myself to a realistic standard. But, like, it's still relatively high. But like, I can't be perfect. But I try to hold myself to a certain standard of… So I try not to miss class. I try not to, like, do stuff like that. Sometimes there's, like, mental things that are going on, then, like, I kind of can't. But yeah."*

Theme 4: Teamwork presented behavioral, social, and emotional challenges to neurodivergent students. The most pronounced struggles include conflict management (e.g., contributing ideas and negotiating what and when work is to be done) and social-emotional challenges (e.g., fear of being judged, imposter syndrome, and sensitivity to constructive criticism).

Although some students enjoyed accountability and leadership opportunities in teamwork, many students who were interviewed reported struggles as a result of their neurodivergent conditions. Of those interviewed, three students experienced imposter syndrome during teamwork due to comparisons and fear of being wrong and corrected, while one student said that she was overly sensitive to constructive criticisms. Three students struggled with conflict management, for instance, contributing ideas (i.e., deferring to teammates despite having ideas to contribute) and negotiating processes (due date and pacing of the group work), echoing findings by Salvatore et al. (2024), with quotes shown below:

> *Sophia "But I think when I get, like, constructive criticism, it can be really hard for me to take. So like, if I'm doing something wrong, and like, you know, it can come off to me as like criticism of, like, you know, like, "You should stop doing this," you know, stuff like that. Or it's just like, you know, maybe this isn't, like, productive or useful when I'm bringing it up. And I remember, like, that interaction with my own teammate kind of hurt. Because I was like, oh, okay, like, I shouldn't—I feel like, again, it's this all-or-nothing kind of mindset."*
>
> *Phoenix "Just the part, I think it's always the parts, of where I want the work to be done at a certain time or at a certain pace."*

Jordan: But I know people who had serious teamwork issues, neurodivergent people, who've had serious teamwork issues.

Lucas "I just worry if my thinking isn't correct like other people."

More than half of the students interviewed invariably expressed teamwork concerns: two students preferred to work alone because they had trust issues with their group mates; one student always sought out other neurodivergent people as group mates but acknowledged the importance of stepping out of their comfort zone; and two other students carried out the majority of their group's work. Propensity for leadership roles varied greatly among the students: four students tended to assume leadership roles during teamwork, while two students avoided it because of self-doubt.

Theme 5: Students identified several critical elements to inclusive learning, as shown in Figure 3. The bars represented the general categories that were central to inclusive learning/teaching, with specific examples suggested by students in the parentheses.

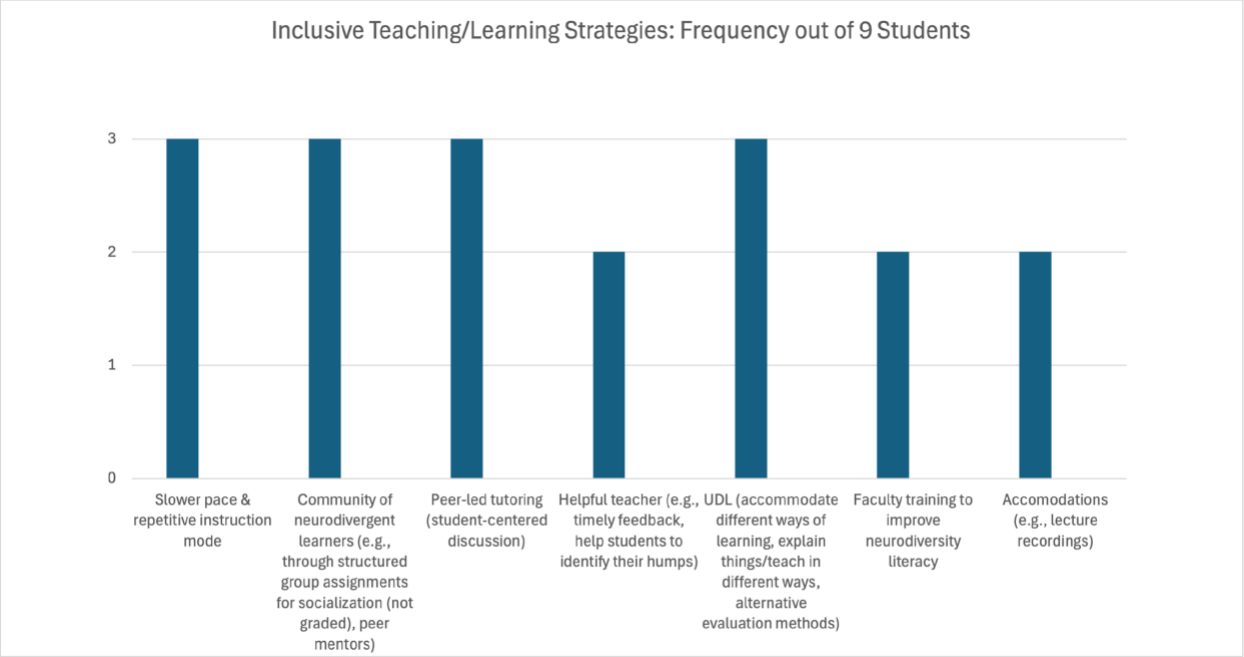


Figure 3. Main codes of teaching/learning strategies, with sub-codes in parentheses

Their responses revealed unmet needs in information processing, social communication, and timely feedback from instructors. When students strive to process information (e.g., course materials) like neurotypicals do, it can lead to frustration and unnecessary mental stress because they compare themselves with faster-learning classmates. Several students exhibited a tendency to this self-defeating comparison.

Sophia: "And I struggle a lot, like, with knowing that I'm different from that and realizing that, like, you know, I feel like if I don't live up to that expectation of what engineering should be, then maybe I'm in the wrong field. Maybe I shouldn't be doing this at all, right? And, like, sometimes it's also, like, again comparison with my own

classmates. Because some of my classmates just pick up these labs really quickly for some reason. … I see so many of my classmates just understand the, like, material so much easier than I am. And I think that contributes a lot to like, oh, you know, I don't feel that great about, you know, me as an engineer or like me seeing myself in that, you know? Yeah."

James: "especially when I think it's like I always try not to compare myself. But sometimes it is kind of frustrating when I can tell, like, it's sometimes it's easier for people to pick up a material faster than I am or I can. Or I have to put in extra work and effort, and then it's kind of—it can get demoralizing."

Theodore "So with ADHD, not being able to process information as quickly as other neurotypicals can, our ability to chunk information really gets hammered, so we can get overloaded very quickly…"

Timely feedback is a critical component to learning and even more so for neurodivergent learners, partly because immediate reward helps them to modulate their deficit in attention and focus, as explained by Theodore:

"So the biggest problem that I have with learning, in general, is feedback, timely feedback. And that is usually reported with just about everybody who I've talked to with ADHD. I'm not sure about neurotypicals. But definitely the people with ADHD, they're unsure of their knowledge. And again, I think it's because of that whole attention to details versus what am I supposed to be paying attention to versus what I'm not?"

Theme 6: All nine students expressed cautiously optimistic views of AI's roles in supporting neurodivergent learners. They embrace AI features that assist in studying (e.g., self-paced tutor, note-taking, summarizing lecture notes), a concept increasingly supported by emerging research on AI tutoring (Baillifard et al. 2025; Qin et al. 2026); planning (e.g., routines, tasks during teamwork); time management; and social and communication (facilitating social interaction, explaining sarcasm, scripting, and providing a safe environment for students to be heard, per Lucas and Oliver).

All except one student have tried ChatGPT for personal use or as required by the courses which they took. ChatGPT's capability to explain concepts emerged as the most agreed-upon asset, while other qualities were also acknowledged by students such as performing mundane tasks (e.g., generating boilerplate computer codes and writing business emails). Students' concerns with AI tools focused on hallucination, accuracy issues (e.g., lack of sourcing/citation), and AI's current inability to explain advanced topics (e.g., quantum physics), as shown in Table 2.

Table 2. Students Usage & Perception of AI

	Perceived Advantages					Perceived Disadvantages			
	Summary power	Explaining basic concepts	Perform mundane tasks	Convenience	Breaking down tasks	Doing things	Hallucination	Advanced topics	Lack of sourcing
James		♦	♦			♦			
Gabriel		♦				♦			
Oliver				♦	♦				
Sophia		♦							
Theodore							♦	♦	
Lucas									
Phoenix	♦								♦
Jordan			♦				♦		
Henry		♦					♦		♦

Discussions

The thematic analysis confirmed what we already knew such as academic challenges (Theme 1) and teamwork difficulties (Theme 4) typical of neurodivergent students. It also provided concrete evidence for neurodivergent strengths (Theme 2), which have received increasing attention (Salvatores et al. 2024; Cherewick and Matergia 2024; Courchesne et al. 2020). Moreover, the results illustrated the very same trait (e.g., rigidity, fixation on routines) that caused challenges can produce positive outcomes during certain teamwork contexts. Helping students to put their challenges and strengths in perspective of the learning context can improve self-awareness. Because self-awareness is the foundation to self-knowledge (knowing who they are, their values, and traits), developing greater awareness of one's weak points and strengths is a necessary condition to better learning outcomes.

This study pointed to potential mechanisms (Themes 2 and 3) connecting teamwork challenges to self-regulated learning (SRL) principles (Yan and Carless 2022). SRL is a critical cognitive and meta-cognitive condition essential for academic learning, in which students proactively set goals, plan, monitor learning processes, and select strategies. SRL requires self-awareness (being aware of one's strengths, challenges, and traits) as well as self-assessment (knowing in real-time how one is performing) (Cárdenas-Robledo and Peña-Ayala 2018). Most of our participants exhibited a keen sense of self-awareness; however, when it is not accompanied by effective self-assessment during teamwork or other learning contexts, a high level of self-awareness could lead to negative outcomes, an interpretation we made based on the lived experiences of James, Sophia, and Oliver. The connection between self-regulated learning and teamwork could inform intervention strategies to facilitate teamwork involving neurodiverse students as they tend to over or under-estimate their own and their peers' contribution (Smyser 2025).

The results explored potential interests of neurodiverse students in using AI to facilitate teamwork and other learning contexts (Themes 5 and 6). Special areas of interests include time management, timely feedback, chunking information, and social communication. These areas tend to be overlooked by academic accommodations. However, AI applications on neurodiverse

learning may be impeded by a few factors. First, although hallucination has been reduced, it remains an issue, where AI tools over-generalize and whip up trends that are not there, a weakness particularly concerning for younger or very literal users. Current AI platforms (e.g., ChatGPT) have yet to accompany their outputs with robust sources or references, a concern raised by several students. Second, AI agents like ChatGPT have yet to be trained on advanced and niche subjects like quantum physics, thereby having very limited ability to adapt to learning applications in those contexts. Lastly, it remains to be seen how AI agents detect learning "humps" or adapt explanations dynamically, as an experienced teacher would, although its language ability could be used to explain basic concepts in simple terms and in different ways. This suggests an additional area of research to imbue empathy and adaptivity in AI tools.

Conclusions

This phenomenological study investigated the learning challenges and strengths through nine interviews conducted on neurodivergent students in engineering and physics programs at a Hispanic-serving, ABET-accredited university. This study investigated the duality between challenges and strengths and explored students' usage and perception of AI tools in teamwork and other learning contexts. Several key takeaways are summarized here.

- Students enhance self-awareness by recognizing their challenges and strengths and by examining how particular traits may serve as strengths or limitations across contexts, including teamwork. While self-awareness is important to discovering one's values and traits, it must be coupled with well-formed self-assessment for a student to thrive in teamwork and other learning contexts. When students lack healthy self-assessment (evaluating how they are performing), they are prone to frustration and low self-esteem. This is supported by education psychology principles such as self-regulated learning (Karlen, Hirt, Liska and Stebner 2021) and should be further examined in engineering education.
- Neurodiverse students possess a wide array of strengths from special interests to pattern recognition, and from honesty to work ethics. Even traits that cause them troubles in one context can produce positive outcomes in other contexts (see Theme 2). This observation demands future investigation into alternative learning contexts that amplify strengths while ameliorating challenges, for example, through experience-based or project-based learning. Several intervention strategies (Figure 3) are viewed favorably by our students, such as slower-paced delivery, timely feedback, and improving neurodiversity literacy among faculty and other university employees.
- Engineering students view AI applications positively and embrace customized support to address their unmet needs. Areas of interest include time management, timely feedback, processing information, and social communication. For instance, AI can help instructors incorporate UDL by creating new and novel ways in which students can demonstrate their grasp of a topic via visual presentations, videos, or interactive simulations. Future work may look into customized AI supports for self-paced tutoring, explaining a concept in different ways, etc., to supplement regular classroom teaching.

These findings provide evidence of the interconnected challenges and strengths associated with neurodiversity, both within and beyond team-based contexts, grounded in thematic analysis and

educational psychology frameworks. This work contributes to a strengths-based perspective that positions neurodivergence as an integral aspect of human variation. Six participants reported imposter syndrome, while four described stigma and a desire to be "accepted" or to "feel normal," underscoring the need for continued efforts to promote neurodiversity acceptance. Additionally, generative AI shows potential as a tool to support neurodivergent engineering students by enhancing their capabilities and promoting more equitable participation in education and employment.

Acknowledgment

This work was supported by the National Science Foundation under Grant No. IUSE-2417557. The views expressed are those of the authors and do not necessarily reflect those of the funding agency. We thank the students participating in the interviews. The authors are deeply humbled to learn from their stories.

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