WIP: Understanding the Experiences of Neurodivergent Learners in Engineering and Computing Majors

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Introduction

In this Work-in-Progress paper, we present our student-driven research into the experiences of neurodivergent learners in Engineering and Computing majors at an R1 institution in the southeastern United States. Neurodivergent people have differences in the brain's functionality that can affect how their brain works and processes [1]. These differences can impact how neurodivergent individuals experience the world compared to neurotypical behavior and thought patterns. However, more universities have recently become more aware and supportive of neurodivergent individuals and significantly increased accessibility to assistive resources [2]. This recognition sparked the interest of an undergraduate student club at a Land Grant, Carnegie R1 institution focused on connecting and supporting neurodivergent learners at the school. From this club, a longer-term collaborative research project has developed in a course-based undergraduate research experience [3]. Through our ongoing investigation into neurodiversity, student researchers pursue individual topics of interest related to the central theme of neurodivergent learners.

Before the start of the study, the authors of this paper explored the subject during a summer pre-freshman research experience, preparing for the course-based experience in the Fall 2023 semester. During the first semester of this study, twenty-two undergraduate researchers joined the project and contributed to implementing a general survey for participants with institutional affiliation. The survey requests information on how participants self-identify and their experiences regarding neurodiversity within the institution. To pursue the data analysis shared in this paper, we used specific questions to categorize participants into categories such as neurodivergence identification and college choice, and we selected engineering and computing undergraduates who self-identify as neurodivergent. We used these categories to compare data and conduct descriptive statistical and thematic analyses of participants' shared experiences. We hope to better understand the experiences of neurodivergent learners in STEM majors, particularly Engineering and Computing, to compare and contrast them to their peers in non-STEM majors and to further refine survey and interview protocols focused on neurodiversity in STEM for future study. This WIP paper includes findings from the initial survey and our analysis in preparation for future work.

Concerning our positionality toward this work, two of our four authors identify as neurodivergent. While we promote a strengths-based approach to neurodivergence, our work does not happen in a vacuum. We understand that deficit framing persists and attempt to identify and respond where appropriate. As a Work-in-Progress in a novel area of research, we find it helpful to implement a belief from the ASD community: *Nothing about us without us*. Having neurodivergent and neurotypical researchers collaborating on work focusing on neurodivergence has been an exciting and effective way to explore our biases and subjectivities.

Literature Review

There is a shortage of thorough research on the implications of neurodiversity in higher education; however, research is fertile on the experiences of neurodivergent students in primary and secondary school. Neurodivergent learners are often framed in unfavorable comparison to their neurotypical peers, e.g., they struggle to focus in class, keep their possessions organized, follow instructions, and develop proficient writing skills related to their neurotypical peers [4]. Of course, not all people who identify as neurodivergent learners experience the same aspects of their neurodiversity. Often, individuals can work with academic advisors to help receive appropriate accommodations, from providing a quiet room to complete work to encouraging breaks, which helps break work down into smaller, manageable tasks [5]. Neurodivergent individuals can use their unique skills to succeed in engineering and science, quintessentially demonstrated by the engineer and inventor Nikola Tesla, who was also neurodivergent [1].

Increasing access and equity for neurodivergent learners in higher education requires advocacy for equal opportunities, resulting in more universities openly accepting neurodivergent students and providing accommodations on campus [2]. This development has led to more neurodivergent students enrolling in higher education than ever before, but despite these positive changes, they still have a lower graduation rate than neurotypical students [6]. However, with increased accommodations and neurodivergent students enrolled in higher education[7], there are more opportunities for researchers to better understand how neurodivergent learners experience and navigate higher education. While this subset of the overall study focuses on neurodivergent learners who are undergraduate engineering and computing majors, our larger project includes all members of our institutional community, i.e., administrators, faculty, staff, and students.

Methods

The *Understanding the Experiences of Neurodivergent Learners in Higher Education* project is in its initial exploratory phase. The study we present here represents the first iteration of a longer design-based research implementation. We intend to develop accessibility resources and tools and raise evidence-driven awareness of neurodiversity in general, particularly the experiences of neurodivergent learners, especially at the institutional level. The results we present are from the first general survey that included primarily quantitative prompts for participants. The only open-ended qualitative data was collected as a follow-up to a quantitative prompt. The survey consists of a self-selection question that diverts participants to questions based on their self-identification as neurotypical or neurodivergent. We did not require anything other than self-identification, as we do not use neurodivergence as a medical construct in our work [8]. We used thematic analysis of the only qualitative response and descriptive statistical analysis to better understand quantitative responses from the Likert scale and other multiple-choice prompts. After Institutional Review Board approval, we distributed the survey through Qualtrics using an individually driven approach. Each student shared survey invitations with various individuals in their personal and professional networks, including any staff, faculty, or administrators with whom they interacted. Our work is currently situated within the context of a Land Grant, Carnegie R1 institution in the southeastern United States.

The survey went live on 10 October 2023 and closed on 11 December. Responses came from individuals in various clubs and organizations, including academic clubs, honors societies, social organizations and clubs, athletic groups, and other class and residential hall groups. Because of this range of participants, we received responses from various majors and each of the majors offered by our institution. To analyze the participants who are undergraduate majors in computing or engineering, we used a subset from the larger pool of data that included participants who identified as neurotypical or neurodivergent. In bounding this subset, we could compare results among participants in the subset and compare them with responses from students in other majors. For the initial survey, we used an operational definition of neurodivergence that emerged from our discussion of several models, primarily from Judy Singer [9], Nick Walker [10], and the 2022 Substack Developer Study [11].

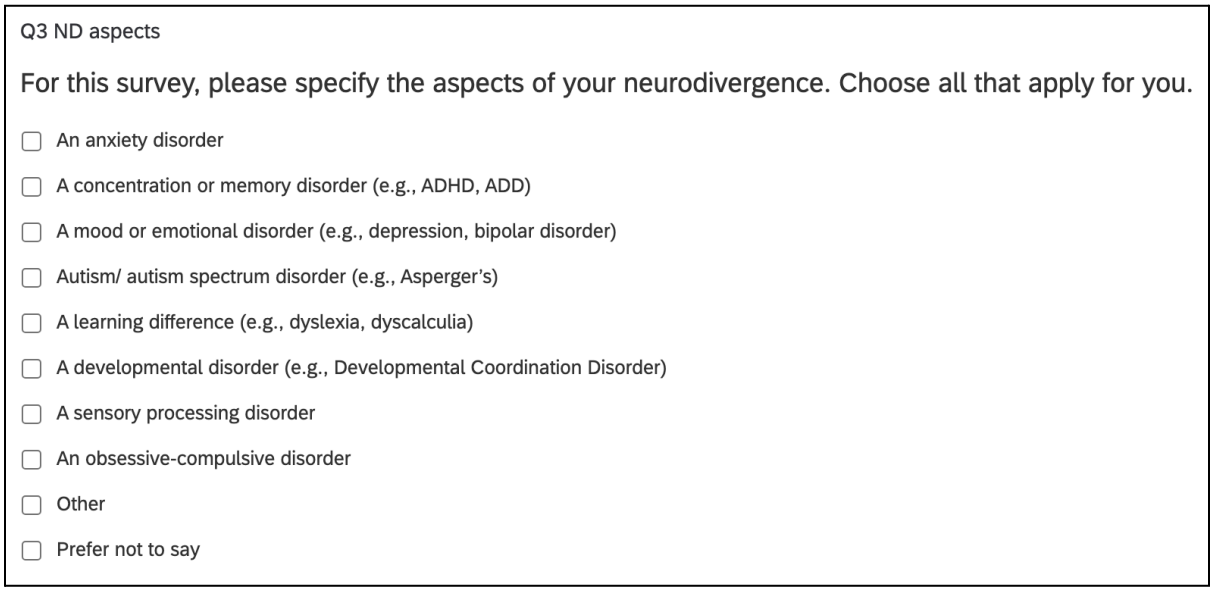

Figure 1. Qualtrics follow-up question to self-identification as neurodivergent

As our primary observation tool, this survey responded to questions that gauge the experiences of self-identifying neurodivergent and neurotypical engineering and computing students. Those who self-identified as being neurodivergent were asked to disclose the aspects of their neurodivergence and a question about potential skills or strengths they believe are due to their neurodivergence. This identifying question provides the groundwork for a study of strengths-based approaches to supporting neurodivergent learners that the first author is pursuing. We attempted to gather evidence to support a general understanding of their experiences. Quantitative questions required participants to rate particular experiences at the institution using a slider ranging from 1 to 5, with one indicating very poor and 5 being excellent, which were helpful in organization and cross-group analysis. We used this slider format to allow participants to respond with a degree of magnitude regarding agreeing or disagreeing with statements. Those who self-identified as neurotypical were also questioned about their thoughts and experiences within the same institution using the same slider format. They were asked to respond based on their perspectives and experiences as neurotypical individuals, focusing primarily on awareness and understanding.

Due to the exploratory nature of this study design, limitations exist in our data collection and subsequent analysis. Although the survey results in this study allow for a better understanding of the experiences of neurodivergent and neurotypical students involved in engineering and computing majors, it is far from comprehensive. Our project is ongoing in other students' related studies that allow for a more thorough understanding by synthesizing perspectives and experiences from a more representative sample of the institutional community. Our bias toward improving the experiences of neurodivergent learners in higher education may not be an intellectual and pragmatic goal for all in our state, requiring us to consistently reflect on our subjectivities as researchers. Two of the authors self-identify as neurodivergent learners, which makes having two neurotypical learners as collaborators ideal for identifying our reflexivities, including assumptions and overgeneralizations. We consistently review our work for logical fallacies that influence interpretation. In addition to addressing positionality, the initial survey collected a relatively small sample size for data analysis, given the institutional size. We chose to pursue our personalized implementation method to avoid current institutional barriers regarding specific topics that would have required lengthy administrative review. However, the process did allow for further insight that we can use in our ongoing research. According to participants' willingness to participate in additional interviews determined in the survey, research pathways in other subtopics in Spring 2024 include detailed interviews, which will allow for a more comprehensive analysis of the experiences of neurodivergent learners in higher education.

Results

To evaluate and further understand the experiences of neurodivergent students attending higher education, researchers collected data from the survey mentioned previously. We analyzed quantitative data using descriptive statistical methods. We used this analysis to better understand the experiences of neurodivergent learners in higher education, with a particular focus on our study subset of undergraduate students in engineering and computing majors.

After cleaning for incomplete data, we had twenty-eight participants, all Engineering and Computing majors, who completed their responses to the distributed survey. The sample consisted of 19 participants who self-identified as being neurodivergent and 9 participants who did not self-identify as being neurodivergent. With a majority of participants (67.9%) self-identifying as neurodivergent, most participants disclosed that they had a specified aspect, as indicated in Table I.

Neurodivergence Aspect	% of Participants
Anxiety aspect	68.4%
Concentration or memory aspect	26.3%
Mood or emotional aspect	5.26%
Autism spectrum aspect	5.26%
Other	5.26%

Table I. Percentage of Neurodivergence Types

Participants who self-identified as neurodivergent learners were asked if they felt they had a special skill or talent, allowing for a better understanding of the relevance of future research regarding strengths-based approaches in higher educational settings. Out of the 19 participants who self-identified as being neurodivergent, ten felt as though they did have a particular skill or talent due to their neurodivergence. These skills included proficiencies in art, calendar, mathematics, mechanics, spatial awareness, music, and other subjects. These participants could select as many talents or skills as necessary to accurately reflect their special skills or talents. From this prompt, results revealed that proficiency in mathematics was most common within this sample, as seen in Table II.

Special Skill or Talent	Participants
Mathematics	7
Artistic abilities	6
Spatial awareness	4
Calendar	2
Mechanics	1
Music	1
Other	1

Table II. Special Skill or Talent Data

Neurotypical participants were also asked about their experience with formal training, institutionally provided accommodations, witnessing discrimination, and willingness to attend training in the future as it relates to neurodivergence. The questions presented and responses that were collected can be viewed in Table III. These results allow for a better contextual understanding of the factors that contribute to the perspectives held by these neurotypical participants.

Question	Response Data
Have you received any formal training or education about neurodiversity and how to support neurodivergent learners in higher education?	Yes - 0.0% No - 100%
Do you think your institution provides sufficient resources and accommodations for neurodivergent learners?	Yes - 33.3% No - 11.1% Unsure - 55.6%
Have you ever witnessed discrimination or unfair treatment towards a neurodivergent individual within your institution?	Yes - 66.6% No - 33.3%
Would you like to participate in a training or workshop focused on better understanding and supporting neurodivergent learners?	Yes - 11.1% No - 44.4% Maybe - 44.4%

Table III. Neurotypical Questions and Responses

Those participants who self-identified as neurodivergent were asked about their overall experience within their institution. The neurodivergent participants were also asked about their communicated neurodivergent statuses, institutionally provided accommodations, and witnessing discrimination. The questions presented and responses that were collected can be viewed in Table IV. These results allow for a better contextual understanding of the factors that contribute to the perspectives held by these neurodivergent participants.

Question	Response Data
Have you communicated your neurodivergent status to your institution?	Yes - 36.8% No - 57.9% Prefer not to say - 5.56%
Is your institution providing specific accommodations for neurodivergent individuals?	Yes - 68.4% No - 0.0% Unsure - 31.6%
Have you encountered any form of discrimination within your institution related to your neurodivergence?	Yes - 36.8% No - 52.6% Prefer not to say - 10.5%

Table IV. Neurodivergent Questions and Responses

A slider was used to question neurotypical learners' familiarity with neurodivergence and the various neurodivergent aspects. The average response score for this prompt was 3.33, with being not familiar at all and five being very familiar. The mode was three, and the range was 3-4. With the variances in responses being so minor, we inferred that participants had a neutral reaction to a statement about their familiarity with neurodivergence.

The same slider system was also used in a secondary question, which asked neurotypical learners to rate their institution's inclusivity towards neurodivergent individuals from their perspective. The average response score for this prompt was 3.667, the mode was 3, the median was 4, and the range was 2-5. This result demonstrates a higher variability in responses, but the overall opinion was neutral, with a slight lean towards participants feeling that their institution was overtly supportive of neurodivergent individuals.

As an open-ended qualitative follow-up question, neurotypical learners were asked how they think the institution could be more supportive of neurodivergent learners. There were a variety of responses showing that participants deliberated potential accommodations to support their peers. For example, one participant suggested, “more individual education styles to accommodate neurodivergent learners.” At the same time, another mentioned that inclusive practices could be “allowing students to state what they need to aid their success and consider these needs and if they are possible to reasonably fulfill.” However, when asked about specific practices that could be used to enhance the learning experience for neurotypical learners, half the participants did not respond or responded with “unsure,” “no clue,” and “idk.” The other half provided responses such as setting times for “for specialized small study groups” or “water breaks during tues/thur classes” and the institution providing “better mental health access would be helpful for everyone including neurodivergent learners.”

We used the same slider system for the neurodivergent learner subset, with one being very poor and five being excellent. The average response score for overall experience within the institution was 3.53, but the mode and median scores were 4. Therefore, neurodivergent participants mainly felt neutral about their experiences overall, with a slight preference for an excellent experience. Following this response, participants were asked to rate their experience related to their neurodivergence within the institution. The average response score for this question resulted in a lower score of 2.83, with the mean and medium being 3. This difference in statistics than before could indicate that participants had worse experiences relating to their neurodivergence rather than in an overall experience context. Both questions ranged from 1 to 5, so the experiences of neurodivergent learners greatly vary depending on the person. In the final usage of this slider system, participants were asked to rate the effectiveness of their institution's provided accommodations, and the average response score was 3.14. The mean and mode were 3, with the range 2-4. This result displays an overall consistent neutral rating of the efficiency of accommodations known or used by participants within their institution.

Discussion

Due to the small sample size acquired by this pilot study, results and interpretations certainly cannot be generalized to every institution or experience of neurodivergent students; however, our emergent findings help continue our work and explore particular aspects of neurodivergence in detail.

In our initial survey results, more neurodivergent students participated than neurotypical students, which we attribute at least in part to self-selection by participants based on their interests and lived experiences. Among the neurodivergent participants, there was a higher proportion of participants who reported an anxiety aspect to their neurodivergence, followed by concentration or memory aspects. Based on these results, it may be implied that future accommodations with STEM-related fields and areas of study may need to focus on resolving the current problems people with anxiety undergo. A higher number of neurodivergent participants indicated they had proficiency in mathematics, as noticed in the survey results. This, too, may indicate institutional change that would allow for strengths-based approaches in STEM fields, an area that will be explored in future research.

The survey results from self-identifying neurotypical participants were used to compare and contrast the experiences of neurodivergent learners. We noted that none of the neurotypical participants had ever undergone formal training or education on supporting their neurodivergent peers. Similarly, a vast majority of participants were unsure or unwilling to participate in future training, which may be attributed to the potential existing stigma surrounding neurodivergent topics. This suggests that a change must be made within institutions to resolve the harmful stigma that neurodivergent learners face. Similarly, the majority of neurotypical participants also noted that they had witnessed instances of discrimination towards neurodivergent individuals, which was not the case for neurodivergent responses. This may show an increased willingness for neurotypical participants to disclose this information or may show that neurotypical participants are more likely to demonstrate discrimination amongst their neurotypical peers rather than in the presence of neurodivergent individuals. In either case, inclusive measures need to be taken by institutions to combat instances of unfair treatment towards neurodivergent

learners. To do so, more resources and educational opportunities should be available to everyone so that people can become more familiar with neurodivergence. Our study shows a basic overall understanding of the term without knowing the defining aspects or other essential nuances.

A reason for not sharing their neurodivergent status could be because the overall opinion of the institution's accommodations is very neutral. With the median being three, the mode being three, and the mean being 3.14, others do not think the accommodations to be very effective. However, the range was 2-4, so they are not considered to be not at all effective either. This neutral feeling by neurodivergent learners towards the effectiveness of accommodations at the institution could be the reason people who don't have accommodations don't seem to urgently feel like they should get them. Most neurotypical students answered that they were unsure, with the following most common answer being no. As this is a work-in-progress paper, we will continue our analysis until the conference and present additional findings that include Spring 2024 data.

According to neurodivergent participants' responses, there is room for improvement regarding the few accommodations offered by institutions of higher education, as well as the policies for maintaining an inclusive learning space. These findings reveal that engineering and computing students within higher education, both neurodivergent and neurotypical, somewhat recognize a need for institutional changes to better the learning and engagement of neurodivergent students. In addition, the accommodations and resources already provided by institutions should be increasingly advertised to all students, as both the neurodivergent and neurotypical participants within this study responded as being unsure about the existence of accommodations offered by their institution.

Conclusion

This Work-in-Progress investigation focuses on understanding the experiences of neurodivergent learners in higher education. As part of ongoing, design-based research, this pilot implementation of data collection and analysis tools has provided important insights into the process and essential feedback from neurodivergent and neurotypical institutional community members.

Future Research

A group of students is studying strengths-based approaches to neurodivergence. Currently, a limited amount of studies focus on harnessing each individual's strengths to help optimize their learning experience in higher education. Some neurodivergent people identify strengths attributed to their neurodivergence [12]. For example, some people, usually those with autism, have unique skills in music, calendars, mathematics, art, mechanics, and spatial awareness. It has been thought that these strengths could stem from neurodivergent people usually having exceptional memory - even better than the average neurotypical person [12]. Acknowledging these skill distinctions is called the "Strength-Based View" because people understand that neurodivergence is not always a negative characteristic [13]. The background of these strengths has been deeply studied, but their practical application, especially in higher education, has not been. There is currently a significant gap within the literature regarding using neurodivergent people's strengths to benefit their learning despite the strengths being highly researched. This

work could focus on creating strategies for success that revolve around an individual's special skills or talents, tailored to accommodate other individuals' strengths and weaknesses.

Another group of students in the overarching project comprises three exploring transitioning from school to work. Neurodivergent individuals often face hurdles in securing and maintaining jobs due to employer bias and challenges attributed to their neurodivergence. Each aspect of neurodivergence can manifest as weaknesses to others, such as ADHD impacting time management. However, with thoughtful accommodations, experiences that neurodivergent workers feel inhibit their success on the job can lessen these issues to avoid negatively impacting their work[14][15].

Another area regarding neurodivergence that students are exploring is digital technologies to support neurodivergent learners. While emerging assistive technologies, such as learning-based video games and online platforms, show promise in supporting neurodivergent individuals in higher education, comprehensive research on their user experience and effectiveness is lacking. Therefore, more research needs to be done in this area to determine how we can implement these technologies into the lives of neurodivergent learners.

References

[1] Cleveland Clinic, "Neurodivergent: What It Is, Symptoms & Types," *Cleveland Clinic*, Jun. 02, 2022. https://my.clevelandclinic.org/health/symptoms/23154-neurodivergent

[2] F. Farrant, E. Owen, F. Hunkins-Beckford, and M. Jacksa, "Celebrating neurodiversity in Higher Education," *The Psychologist*, May 09, 2022. https://www.bps.org.uk/psychologist/celebrating-neurodiversity-higher-education (accessed Feb. 08, 2024).

[3] E. L. Dolan, "Course-based undergraduate research experiences: Current knowledge and future directions." Natl Res Counc Comm Pap, 1, 1-34. 2016.

[4] E. Burns and S. Bell, "Voices of teachers with dyslexia in Finnish and English further and higher educational settings," *Teachers and Teaching*, vol. 16, no. 5, pp. 529–543, Sep. 2010, doi: https://doi.org/10.1080/13540602.2010.507964.

[5] K. Acton and D. Huijg, "Relaxed Pedagogy: Relaxing Teaching and Learning in the University," *The Post-Pandemic University*, Sep. 10, 2020. https://postpandemicuniversity.net/2020/09/10/relaxed-pedagogy-relaxing-teaching-and-learning-in-the-university/ (accessed Feb. 08, 2024).

[6] T. Bakker, L. Krabbendam, S. Bhulai, M. Meeter, and S. Begeer, "Study progression and degree completion of autistic students in higher education: a longitudinal study," *Higher Education*, vol. 85, pp. 1–26, Mar. 2022, doi: https://doi.org/10.1007/s10734-021-00809-1.

[7] P. Dwyer, E. Mineo, K. Mifsud, C. Lindholm, A. Gurba, and T. C. Waisman, "Building Neurodiversity-Inclusive Postsecondary Campuses: Recommendations for Leaders in Higher

Education," *Autism in Adulthood*, vol. 5, no. 1, Feb. 2022, doi: https://doi.org/10.1089/aut.2021.0042.

[8] S. Baron‐Cohen, "Editorial Perspective: Neurodiversity–a revolutionary concept for autism and psychiatry." Journal of Child Psychology and Psychiatry, 58(6), 744-747. 2017.

[9] J. Singer, "Neurodiversity: Definition and Discussion, Reflections on Neurodiversity." [Online]. 2019. Available: https://neurodiversity2.blogspot.com/p/what.html

[10] N. Walker, "Neurodiversity Some Basic Terms and Definitions," AUTISTIC UK [Reprint]. 2014. Available: https://static1.squarespace.com/static/618309342c2ee8376ef9f36e/t/6387e9ca81597b3880147ba0/1669851598123/NickWalker_NEURODIVERSITY-SOME-BASIC-TERMS-AND-DEFINITIONS.pdf

[11] Stack Overflow, "2022 Developer Survey." Stack Overflow. [Online]. 2022. Available: https://survey.stackoverflow.co/2022

[12] D. A. Treffert, "The savant syndrome: an extraordinary condition. A synopsis: past, present, future," *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 364, no. 1522, pp. 1351–1357, May 2009, doi: https://doi.org/10.1098/rstb.2008.0326.

[13] E. Griffin and D. Pollak, "Student experiences of neurodiversity in higher education: insights from the BRAINHE project," *Dyslexia*, vol. 15, no. 1, pp. 23–41, Feb. 2009, doi: https://doi.org/10.1002/dys.383.

[14] N. Doyle, "Neurodiversity at work: a biopsychosocial model and the impact on working adults," *British Medical Bulletin*, vol. 135, no. 1, pp. 108–125, Sep. 2020, doi: https://doi.org/10.1093/bmb/ldaa021.

[15] S. C. K. Shaw, S. McCowan, M. Doherty, B. Grosjean, and M. Kinnear, "The Neurodiversity Concept Viewed through an Autistic Lens," *The Lancet Psychiatry*, vol. 8, no. 8, pp. 654–655, Aug. 2021, doi: https://doi.org/10.1016/s2215-0366(21)00247-9.