Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46756

Engineering Identity, Belonging, and Neurodiversity in a Co-Op Based Learning Program

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Introduction

In this research-track paper, we seek to identify the relationship between engineering identity and belonging and neurodiversity in a co-op based program. Neurodivergent characteristics, such as attention to detail, creativity, and pattern recognition, align well with careers in STEM (Science, Technology, Engineering, Mathematics), yet retention of neurodivergent students within engineering programs is lower than neurotypical students [1]. Neurodivergent students who graduate or attempt to enter the workforce in a STEM discipline face bias and decreased success rates in job attainment after graduation [2]. By exploring neurodiverse engineering students' engineering identity and sense of belonging in a co-op based engineering program, we can identify potential pathways towards an engineering career for neurodiverse individuals and identify ways to better support neurodiverse students in their pathway to graduation.

Co-Op Based Program Context

[Program X] is a co-op based engineering program. Students typically complete their first two years of engineering curriculum at community colleges from across the nation, transfer to Program X where they complete a semester that consists of taking technical courses, completing an industry project in collaboration with industry partners, and attending professional development seminars and workshops, and complete the last two years of their degree while in paid engineering co-op positions [3].

In addition to programs to develop technical, design, and professional skills, Program X facilitates opportunities for students to develop a sense of community the moment they start in the program, in recognition of the importance of community in developing students' sense of belonging and engineering identity [4]. Students who opt to complete their first semester on campus live in shared accommodations where they are able to engage in collaborative learning outside of the class environment and build camaraderie [5]. Cohort bonding activities that include recreational and co-curricular activities that foster students' physical and mental well-being, such as hiking, kayaking, or watching hockey games, are facilitated alongside academic and engineering professional skills development activities. Social activities that can be accomplished virtually, such as game-based activities, are facilitated in a hybrid setting to include students who opt to complete the first semester remotely, as well as during the last two years of the program where students are working in co-ops across multiple locations, both within the United States and beyond [6]. Promoting these activities also highlight the importance of leading holistic and well-balanced lifestyles [7].

Literature Review

Engineering Identity and Sense of Belonging

Developing an engineering identity is a significant first step for students that may influence their academic performance, personal and professional development, motivation to engage and persist in engineering, and assimilation into an engineering community [8]. A study that examined engineering identity with almost 1,000 students (n=969) revealed that sense of belonging was closely statistically correlated to engineering identity, more so than competence as measured by the GPA [9]. These findings indicate the equal importance of facilitating opportunities for students to develop a sense of belonging in engineering, starting in the early stages, and sustaining these opportunities for the duration of their academic journey [10] alongside programs meant to develop technical skills.

Students most equate the development of engineering identity to their ability to competently make design decisions, share knowledge and ideas in the context of working in teams, take ownership of any consequences related to their decisions and actions, and communicate technical information effectively [11]. Having the confidence to say "I am an engineer" based on the ability to perform the aforementioned functions as a student takes some time; however, the same study yielded marked differences between students in the first year and those who are already more advanced in their academic careers (e.g., juniors and seniors) [11]. These findings are in keeping with Tonso's work on engineering identity [12], which defines the experience of being an engineer and being part of an engineering community as a *sense of belonging*, making it critical to the development of engineering identity, and, consequently, students' motivation to engage and persist in engineering [13], [14]. Promoting sense of belonging needs to critically start in the first year and should be sustained throughout the academic journey; specific strategies for promoting sense of belonging such as calling students engineers and facilitating programs that engage and welcome first year students to the institution's engineering community (such as the school or college) correlate with improving retention and persistence and, consequently, the development of engineering identity [11], [15].

Neurodiversity

Prior work highlights the important role of neurodiversity in influencing feelings of belonging in engineering education and the engineering workforce. A study by Bolding et al., (2023) found significantly lower self-reported belonging level in neurodivergent versus non-neurodivergent students [16]. Neurodivergent students have described additional stress and the invisible labor of overcoming challenges to their sense of belonging in engineering programs [17]. In Cage & Howes (2014), former students with autism reported their "outsider status" as influencing their experience and their decision to drop out of university [18]. Depression and anxiety commonly co-occur with neurodivergence [19], [20], and these too have been connected to feelings of isolation and sense of belonging in the engineering workplace [21]. Neurodivergent students who seek job opportunities often encounter a barrier because the interview process is set for

neurotypicals [22]. Students with autism who had job placements during university reported anxiety around fitting in around the workplace and also discussed the negative physical and emotional effects of hiding their autism [23]. While a growing body of research connects neurodivergent identity to sense of belonging in engineering, little work to date has studied the relationship between neurodivergent status and engineering identity and belonging in non-traditional engineering programs.

Historically neurodivergent students have been underrepresented in engineering [24]. However, a growing body of studies are showing how the characteristics of neurodivergent students, such as pattern recognition and visual-spatial abilities, are not only suited for engineering but are desired characteristics of engineers[1], [25], [26], [27], [28]. The neurodivergent students within engineering face academic difficulties and often have lower retention rates when compared to neurotypical students [2]. Studies suggest a variety of ways to create a more inclusive learning environment that better supports neurodivergent students such as implementing universal design of learning (UDL) and emerging technologies like AI in the classroom [4]. Others suggest that co-curricular work-based learning will allow for better accessibility for all students due to the flexibility the program allows and the ability to incorporate hands-on experiences [29],[30]. However, other studies note that work-based learning can also negatively impact students due to a lack of support for individuals within the corporate setting [23].

Methods

In this mixed methods study, we explore the research question: "Is there a significant difference in engineering identity and sense of belonging between neurodivergent and neurotypical engineering students in a work-based learning program?"

Description of Participants

Participants of this study (n=130) were all students in a co-op based engineering program, [Program X], and in their junior or senior year of study. Of these students, 37% identify as having a disability, 34% as nontraditional age (over the age of 24), and 40% as low or lower-middle income. Race and gender identities are listed below in Table 1.

Table 1: Participant Demographics (N=130)

Race Identity	American Indian or Alaskan Native	Asian	Black or African American	Hispanic, Latino, or Spanish Origin	Multiracial	White
	<1%	9%	7%	17%	9%	57%
Gender Identity	Men	Women	Transgender, Nonbinary, Agender, and/or Genderqueer			
	70%	26%	3%			

Data Collection

Data were collected through a Qualtrics survey in 2023 and 2024. All students in [Program X] were invited to complete a survey on engineering identity, sense of community (university, engineering discipline, and program), co-op information/experiences, and demographic information. The full survey is attached in the appendix [redacted for review].

The engineering identity items [31], sense of community items [32], demographic questions [33], and an open-ended question on co-op experiences were included in this study. The engineering identity and engineering community surveys have been run on, developed, and tested on similar populations. The engineering identity and sense of community items were measured on a 7-point Likert scale (0- Not at all, 6- Very Much So). The open-ended question asks "Has the co-op experience or job-search process affected your feelings of belonging in engineering, and if so how?"

Data Analysis

The most recent survey data was included in this study. If a student completed the survey in 2023 and 2024, only the 2024 responses were considered. If a student completed the survey in 2023 and not 2024 (i.e., graduated in between survey distributions), their 2023 responses were included in the study.

Neurodivergent students were identified using their response to an item added in 2024 to capture neurodiversity identity, "Do you identify as neurodivergent?", or, in the 2023 distribution, if they indicated a neurodivergent diagnosis (i.e. ADHD, Autism) in their response to "How would you describe your disability/ability status? If you wish or as necessary, please indicate your specific disability/ability statuses in the space below." Those who did not indicate a neurodivergent identity in 2023 or 2024 were included in the neurotypical analysis.

Once the data were cleaned, an average score for each factor per student was calculated. There were two overall factors: Engineering Identity and Sense of Community. Within Engineering Identity, there were three items: Recognition, Interest, and Performance. Within Sense of Community, there were three items: Sense of Community with the School/University, with the Engineering Discipline, and with the Engineering Program. Descriptive statistics were run for each factor and item, for both the neurodivergent and neurotypical samples.

The average scores for neurodivergent and neurotypical students were tested for normality, where $|skew|>2.0$ and $|kurtosis|>7.0$ are considered non-normal data [34], [35]. The data that demonstrated acceptable levels to fit the assumption of normality were then evaluated with t-tests because t-test have an assumption of normality. Thus, a Welch's two-sample t-test for equal means was conducted on Engineering Identity (all items), Sense of Community (all items), Engineering Identity (Recognition), Sense of Community (University/School).

Next an emergent thematic analysis of the open-ended question on their co-op experience was conducted. Each response was coded with "Yes/No" to indicate if the co-op experience or job search process impacted feelings of belonging in engineering. Then a code was used to indicate if the impact indicated was positive, negative, both, or unclear. Finally, a short thematic code was used to indicate key themes emerging from the response. These were refined for consistency in a second pass through the data. Responses varied in length (1-70 words), and two codes were used as needed for a response. Both quantitative and qualitative comparisons of the neurodivergent and neurotypical responses were included in the analysis (i.e., counts of codes, and overall themes from data).

Results

Quantitative Results

The descriptive statistics for each of the factors are shown in Tables 2 and Table 3. Engineering Identity Interest, Engineering Identity Performance, Sense of Community Engineering Discipline, and Sense of Community Engineering Program were found to have skew>|2.0| and/or kurtosis>|7|. These factors were treated as non-normal distributions and therefore not included in further quantitative analysis.

The results of the t-tests (Table 4) indicate no significant differences ($\alpha = 0.05$) for engineering identity (overall), sense of community (overall), engineering identity recognition, and sense of community school between neurotypical and neurodivergent students in Program X.

Table 2: Descriptive statistics for engineering identity factors for neurotypical and neurodivergent samples

	Recognition		Interest		Performance		Engineering Identity All Items)	
	Neurotyp.	*Neurodiverg.*	*Neurotyp.*	*Neurodiverg.*	*Neurotyp.*	*Neurodiverg.*	*Neurotyp.*	*Neurodiverg.*
Mean	5.43	5.39	5.67	5.81	5.33	5.36	5.39	5.47
Std Dev	0.69	0.96	0.70	0.45	0.95	0.84	0.66	0.55
Median	5.7	6.0	6.0	6.0	5.8	5.6	5.6	5.6
Mode	6	6	6	6	6	6	6	6.00
Range	3.00	3.67	4.67	1.67	4.50	3.75	3.06	2.07
Kurtosis	1.0	2.6	15.7	5.1	3.8	5.5	2.8	1.1
Skew	-1.3	-1.8	-3.5	-2.5	-1.9	-2.1	-1.7	-1.3

Table 3: Descriptive statistics for sense of community factors for neurotypical and neurodivergent samples

	School		Engineering Discipline		Program		Sense of Community All Items	
	Neurotyp.	*Neurodiverg.*	*Neurotyp.*	*Neurodiverg.*	*Neurotyp.*	*Neurodiverg.*	*Neurotyp.*	*Neurodiverg.*
Mean	5.45	5.52	5.64	5.52	5.44	5.21	5.55	5.44
Std Dev	0.64	0.59	0.55	0.69	0.70	1.00	0.56	0.65
Median	5.6	5.6	5.8	5.8	5.6	5.6	5.7	5.6
Mode	6	6	6	6	6	6	6	6.00
Range	2.60	2.40	2.90	2.30	2.80	4.60	2.70	2.20
Kurtosis	1.5	2.7	5.7	1.1	0.9	6.7	4.2	1.3
Skew	-1.4	-1.6	-2.3	-1.5	-1.3	-2.3	-2.0	-1.5

Table 4: Results of Welch's two-sample t-tests for equal means

Factor	Neurotypical Mean (n = 100)	Neurodivergent Mean (n = 30)	p-Value
Engineering Identity (All Items)	5.39	5.47	0.53
Engineering Identity (Recognition)	5.43	5.39	0.83
Sense of Community (All Items)	5.54	5.44	0.46
Sense of Community (University/School)	5.45	5.52	0.57

Qualitative Results

Out of the 119 responses (n=91 neurotypical, n=28 neurodivergent) to the prompt "Has the co-op experience or job-search process affected your feelings of belonging in engineering, and if so how?", 20% of the neurotypical students and 18% of the neurodivergent students felt that the co-op/job search experience had no effect on feelings of belonging to engineering. Out of those who indicated they felt it did have an impact, for neurotypical students, 16% felt it was an overall negative impact, and 68% felt it was overall positive. For neurodivergent students who indicated the co-op experience/ job search process impacted their feelings of belonging in engineering, 24% indicated an overall negative impact, and 43% indicated an overall positive impact. The remaining indicated both a positive and negative impact, or impact could not be determined from their response.

Reasons for the impact on feelings of belonging included things like the ability to obtain a job positively impacted feelings of belonging; the co-op experience itself and gains in confidence, skills, knowledge, and ability were all discussed. Feelings of recognition, primarily from the co-op experience, but also from the job search process were indicated as positively impacting feelings of belonging. From the job search process, rejections, not getting a job, applications not being responded to, and the job search process itself were all cited as having a negative impact on feelings of belonging.

Many students reported setbacks during the job search process that had a negative impact on their feelings of belonging. One neurotypical student shared, “I have been an unlucky one to not be able to find a co-op and that seriously has affected the confidence in myself as an engineer. It affects my feeling of belonging in a bad way.” This feeling was exacerbated for one neurotypical student by comparison to their peers, “Seeing people quickly get co-ops and internships smakes [sic] me feel like I'm not that good.” Others recognized the job search as a challenge, but not something that affected their sense of identity and belonging. As one neurotypical student wrote, “No it hasn’t [affected my feelings of belonging in engineering], the workforce is always competitive, I believe one will always have to compete for an ideal position.” Once students secured an internship or job, these negative feelings abated for some students. One reported that they, “Felt more like [they] belonged” after finding a job. Another neurodivergent student shared, “The job-search experience has depleted my feelings of belonging in engineering because of the rejection and pleading for opportunity. My co-op has elevated my feelings of belonging in engineering through consistent collaboration with others as well as an involvement in the industry community through industry events such as conferences.”

Survey respondents from both neurotypical and neurodivergent groups discussed imposter syndrome but with contrasting experiences. Two students described the job search and co-op experience as having positive effects on their imposter syndrome. A neurotypical student wrote, “It has been the thing that cured my imposter syndrome. It gave me the confidence that I am capable.” A neurodivergent student stated that, “Being immersed in the day to day trials of engineering, surviving, thriving, and bringing value to my teams has helped to quell the anxiety and imposter syndrome of being a young engineer.” Others experienced no impact on their imposter syndrome; one neurodivergent student shared, “I still fight imposter syndrome even though I have excelled in my Co-Ops.” There was no clear connection between neurodivergent status and positive, negative, or neutral effect on feelings of imposter syndrome.

One neurotypical student described the perspective and motivation gained from the co-op experience and community: “It makes me love engineering more, and really value the mindset and work engineers do. It also emphasized to me the importance of being a social and very hands on engineer, taking technical knowledge and physical crafting skills to bring to fruition solutions to problems. It really drives me to become a difference maker like the peers around and before

me, allowing me to stand on the shoulders of giants." Only one student (a neurodivergent participant) compared their experience in a co-op based program to a traditional engineering program, stating, "I have gotten a lot of industry knowledge and it seems like that knowledge sticks more and is more impactful than if I went to the traditional university."

Students overall felt growth in confidence related to work experience. Neurotypical and neurodivergent students respectively discussed how "co-op experience has definitely helped me feel belong in my future engineering career" and that "Having co-op/internship experience makes me feel much more prepared to join the workforce after graduation". Although students from both groups described an increase in confidence in their ability to perform as a result of co-op work, only students from the neurotypical group explicitly reported that they felt recognized by colleagues as a full time engineer. Several students discussed how "[they] have had people at my work treat me as an employee and not just an intern/co-op" and that they were "recognized as an engineer by my coworkers on my team and other departments." Although many neurodivergent students described a growth in confidence, none of them described this type of recognition of themselves as an engineer by their colleagues.

Overall, a variety of factors affect student's feeling of belonging. The job search process negatively affected both neurodivergent and neurotypical students. Students discussed imposter syndrome but there was no connection between effects of co-ops on imposter syndrome and neurodivergence. Both groups of students experienced an increase in confidence related to work experience, but only neurotypical students described being recognized by colleagues as a full time engineer.

Discussion

The results of this study and [Program X]'s co-op-based learning model continue to support the positive outcomes of co-op experiences on engineering identity and sense of belonging. The means for all sub-groups were higher than 5.2 (out of 6), and the qualitative analysis yielded many statements about the positive effect of co-op experiences. Students stated that working around other engineers and being recognized as an engineer by others had a large impact on their confidence, identity as an engineer, and sense of belonging. This aligns with previous work on the value of developing students' identity and belonging to an engineering community [11], [12].

This quantitative analysis of survey responses showed no difference between the engineering identity and sense of community for neurodivergent and neurotypical students. A different study reported that neurodivergent students had a lower sense of belonging [16]. Results may differ due to the survey being taken at the college of engineering level rather than the program level. The lack of difference between neurotypical and neurodivergent students in this study, in which students are in a co-op-based learning program, also contrasts with a study that found that work-based learning negatively impacted autistic students [23]. This latter study posited a lack of

support for the autistic individuals as a potential reason for their negative experiences on co-op, which is much different from the large quantity and variety of supports that students in this study experience as part of the [Program X] co-op-based learning model. More research needs to be done to explore identities, senses of belonging, and experiences of neurodivergent and neurotypical students in a variety of engineering education contexts. Additionally, research should explore which supports are more positively impactful for neurodivergent students.

While neurodivergent and neurotypical students both reported that the co-op experience has a positive effect on their confidence, only neurotypical studentions mentioned being recognized by their colleagues as an engineer. A previous study suggested that students with autism face challenges due to feeling the need to conform and hide their true self in order to succeed which causes concerning amounts of emotional and physical pressures on students [23]. There may be a correlation between lack of recognition and the student's perceived need to fit into the environment. However, further research needs to be done to determine if neurodivergent students experience a lack of recognition.

While the co-op experience tended to have a positive effect on students, the job-search process negatively affected neurotypical and neurodivergent students. The experience of being rejected from jobs may have a greater impact on neurodivergent students due to the prevalence of rejection sensitivity dysphoria (RSD) in people with neurodivergent diagnoses. RSD occurs in episodes that are commonly triggered by rejection, criticism, and rejection of self due to falling short or being perceived as falling short of one's own standards [36]. Episodes of RSD can leave the person in physical and/or emotional pain whilst feeling alone and isolated. As a result, neurodivergent students may need more support during the job-search process [37]. More research needs to be done on the impact of the job search process on neurodivergent students and how to support them in the job-search process.

Limitations and Future Work

Although this work begins to explore these constructs, more research needs to be done on the intersection of engineering identity, belonging, and neurodiversity. The qualitative data included allows some insight to the connection to co-op and job search experiences, the quantitative findings presented here are not longitudinal and do not provide insight into why no significant difference is found between neurodivergent and neurotypical feelings of belonging and engineering identity. Future studies could include interviews exploring supports that positively impact neurodivergent students during the job-search process and while on co-ops and provide insight into why neurodivergent students are showing strong sense of belonging. Interviews could also provide additional understanding of RSD in neurodiverse engineering students in co-op programs. Finally, interviews and surveys could explore students' sense of belonging in industry rather than sense of belonging in a program.

Conclusion

In this paper, we explored the engineering identity and sense of belonging for neurodivergent engineering students in a co-op based program. Quantitative results (n=130) show no significant differences between neurodivergent and neurotypical students in [Program X] in engineering identity and sense of belonging. Average scores in these constructs show overall strong sense of belonging (neurotypical: 5.55, neurodivergent: 5.47 out of 6) and engineering identity (neurotypical: 5.39, neurodivergent: 5.47). Qualitative results show engineering co-op experiences can have positive impacts on sense of belonging in engineering, while the job search process can have a negative impact. Qualitative results revealed unique challenges for neurodivergent individuals on co-op that align with literature in these spaces. We observed neurodivergent students were less likely to report being recognized as engineers by colleagues, which might relate to the pressures they feel to conform or hide their true selves, and additional challenges with the job search process which align with the experiences of rejection sensitivity dysphoria. These results indicate co-op experiences as a potentially beneficial pathway for bringing more neurodiverse individuals to the engineering workforce.

Acknowledgements

This work was supported by NSF Award #.

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