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Work-In-Progress: The Intersection of Neurodivergent Identity, Creativity, and Innovation among Engineering Students

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Abstract

This work-in-progress research examines artistic creativity and innovation self-efficacy (ISE) among neurodiverse students (neurotypical [NT] and neurodivergent [ND]) through self-portrait drawings and surveys. With engineering emphasizing diverse problem-solving approaches, understanding neurodivergent contributions is critical for fostering innovation and inclusivity. In a junior-level environmental engineering course, students created a monster drawing with specific constraints and completed an ISE survey. Drawings were assessed for Creative Work (CW) by an art professor, and CW scores were compared with ISE survey results to explore correlations. Among 37 students, 11 identified as ND or "Maybe ND." Students uncertain about their neurodivergent status (e.g., ADHD, anxiety, depression) excelled in artistic categories like balance/uniformity, color use, and overall design but reported low ISE scores, suggesting identity uncertainty may influence self-efficacy despite demonstrated creative strengths. Anxiety was associated with high artistic concept/design scores (average 8.2), while students who self-reported having ADHD showed lower CW performance, excelling only in balance/uniformity. Across both ND and NT groups, CW and ISE scores appeared inversely correlated. These findings suggest that neurodivergent identity uncertainty may affect self-efficacy even in students with strong creative capabilities. The complex relationship between ISE and creativity in neurodiverse populations warrants further exploration to better understand and support innovation in engineering education.

Keywords: Neurotypes, Neurodivergence, Innovation Self-Efficacy, Artistic Creativity, Self-Portrait Drawings.

Introduction

Cognitive diversity among individuals could be beneficial in engineering. In particular, the benefits of neurodivergence among engineering students and professionals have not been widely studied. In this research, we explore whether neurodivergent (ND) students exhibited higher levels of artistic creativity and/or innovation self-efficacy. This work was motivated by previous research linking specific types of neurodivergence, such as ADHD, to creativity. However, these studies have primarily focused on children or adults outside the context of engineering, leaving a critical gap in understanding within this field. The following paragraphs review the complex relationship between neurodiversity, creativity, and innovation, providing a relevant background. We begin by defining neurodiversity, followed by studies exploring ND and creativity, and then correlations among different types of creativity.

Estimates suggest that up to 20% of the population could be considered neurodivergent [1]. Common types of neurological differences clinically diagnosed as "disorders" include Attention Deficit/Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), dyslexia, and others. This diagnostic language and framework align with the medical model of disability, which views these conditions from a deficit-oriented perspective. An alternative is the neurodiversity framework, which adopts an asset-based perspective, emphasizing the unique strengths and contributions of ND individuals. It is also important to note the challenges in

diagnosing these conditions and that access to healthcare varies among demographic groups. Consequently, this research uses a self-identification model to better capture the diversity of experiences among participants.

Studies have found links between ADHD and creativity. Hoogman et al. [2], for example, reviewed 31 behavioral studies on creativity and ADHD, suggesting that ADHD is associated with increased divergent thinking. Their findings indicated that individuals with subclinical ADHD symptomatology exhibited even stronger links to creativity than those with clinically diagnosed ADHD. The complexity of these findings was influenced by variables such as how creativity was measured, how ADHD was determined, and the participants' ages. Issa [3] conducted studies with adults, finding that individuals with ADHD demonstrated preferences for originality, nonconformity, generating novel ideas, and seeking novelty. Boot et al. [4] explored creativity in different domains among adults with ADHD. They found that the ADHD group showed higher creativity in mechanical/scientific, performance, and artistic creativity. However, no significant differences were found in self/everyday or scholarly creativity. Similarly, Boot et al. [5] noted that subclinical ADHD symptoms, particularly those related to hyperactivity rather than inattention, were associated with higher flexible creativity. This subclinical group may correspond to individuals who self-identify as “maybe neurodiverse,” recognizing they exhibit some symptoms but do not meet clinical diagnostic thresholds. These thresholds vary over time and may not equally represent all demographic groups, highlighting the need for inclusive and flexible approaches to neurodiversity research.

Zhang *et al.* [6] found that more creative students performed better in both scientific creativity and artistic creativity. Additionally, students who excelled in either scientific or artistic creativity - or both - demonstrated a well-developed switching function, an essential component of cognitive flexibility. Their study also identified differences in the manifestations of scientific and artistic creativity based on variations in cognitive control, highlighting the nuanced interplay between cognitive processes and creative output. These findings underscore the potential benefits of creativity in engineering education and practice. Creativity, particularly in scientific and artistic domains, plays a critical role in fostering innovation, problem-solving, and adaptability - key traits for success in engineering. The above studies suggest that exploring the artistic creativity and innovation attitudes of neurodiverse engineering students could yield compelling insights. By examining how cognitive diversity impacts creative problem-solving and design thinking, educators and researchers may better understand how to cultivate inclusive environments that leverage diverse talents to advance engineering education and practice.

Research Questions

To better understand the relationship between neurodiversity, artistic creativity, and innovation self-efficacy in engineering students, this study seeks to address the following research questions:

- RQ1. Are there similarities or differences among the artistic creative work (CW) characteristics between ND and NT engineering students?
- RQ2. Are there similarities or differences among the Innovation Self-Efficacy (ISE) scores of ND and NT engineering students?
- RQ3. Are there similarities or differences among correlations between ISE and total CW scores for ND and NT engineering students?

Methods

This research was conducted as part of a larger study focused on innovation self-efficacy. The study included Junior and Senior level undergraduate engineering students enrolled in a fall 2023 Water Chemistry course. Most students in the course were majoring in Environmental Engineering. In the first week of the semester, students were assigned the "Meet the Monsters" assignment, where they were asked to draw themselves as monsters and post their results to a discussion board. Instructions prompted students with simple requirements for the monsters, such as the mouths on their characters should represent the number of languages they speak, or the number of legs should represent the number of countries the student had stepped foot in, etc. Students were allowed to customize their drawing however they liked, including utilizing different mediums. Examples of the student drawings are shown below in Figure 1.

Figure 1. Example Monster Drawings (the highest scoring students in total CW – from left to right: NT with 85 CW, Maybe ND with 85 CW, Yes ND with 88 CW).

In the third week of the semester, students were offered the opportunity to complete a survey that measured their innovation self-efficacy (ISE) and concluded with demographic items. The survey included 15 statements with response options of one. These questions measured innovation self-efficacy (ISE) using the Very Brief Innovation Self-Efficacy scale, innovation interest (INI) using the Innovation Interests scale, and innovative work goals using the Career Goals: Innovative Work scale (IW), all out of 7 points (adapted from [7] and [8]). The end of the survey prompted students to identify their gender identity, race/ethnicity, and whether or not they identified as Neurodivergent (ND). If the students answered either Yes or Maybe ND, they were asked to list which type(s) of ND they identified with. 6 consenting students identified as Yes ND, 5 as Maybe ND, and 25 as NT.

Overall, there were 37 students who consented to participate in the research and completed both the monster drawing and survey (representing 82% participation among the 45 students enrolled in the course). Research participation was incentivized by the reward of choosing either in-class extra credit or a $10 gift card. The drawings from students who consented to participate in the research (IRB Protocol 23-0388) were previously analyzed for the study [8]. An art professor and 3 undergraduate engineering students individually created 10 sub-categories based on artistic effort (AE) and scored the students on a scale of 10 points in each category [8]. The sub-categories were then totaled to produce the total creative work scores.

In this study, the data were initially separated by ND status, where Yes and Maybe ND students were grouped into an ND category (n=11) and NT students were grouped into a separate NT category (n=26). Six students identified as Yes neurodivergent: three with anxiety (one comorbid

with PTSD), three with ADHD (one comorbid with Autism). Five students identified as Maybe neurodivergent: two with anxiety (one comorbid with ADHD and depression, and one comorbid with ADHD), four with ADHD (counting the comorbidities from above). The population was then separated further into Yes ND, Maybe ND, and NT groups to analyze if the behavior of the Maybe ND group deviated from the Yes ND group. Simple statistical tests were conducted in Excel. Previous research has found that the t-test is robust to ordinal data and small sample sizes [9]. Correlations were conducted in IBM SPSS.

Results

RQ1. Are there similarities or differences among the artistic creative work (CW) characteristics between ND and NT engineering students?

Table 1 summarizes the average, median, standard deviation, and range for each of the 10 sub-categories of creative work (CW). The population has been separated to produce scores to compare the neurotypical (NT) population to the neurodivergent (ND) population. The ND group scored slightly higher than the NT group in every category besides Balance/Uniformity. A simple t-test found that there were no significant differences between the NT and ND students (p-values in 2-tailed heteroscedastic tests all 0.24 or higher). The average total CW scores were similar between the ND and NT students, 62.5 and 59.3, respectively (see Figure 2). This data shows there are no significant differences between the CW scores of the NT and ND groups.

Table 1: The average scores in each sub-category for the ND and NT groups (the top section NT group followed by the ND group below).

ND (n=11)	Average Scores for ND Group (based on Pre-survey)											
	Line / Markmaking	Time / Dedication	Proportion / Perspective	Balance / Uniformity	Use of Color / Value	B/W Shading	Ambition	Craft / Techniques	Experimentation	Concept / Overall Design	Total CW	pre- ISE score
Average Score	6.0	6.4	4.0	7.2	6.8	6.3	5.8	6.3	6.7	7.1	62.5	3.7
Median Score	5.0	6.0	5.0	6.0	6.0	6.0	7.0	7.0	7.0	7.0	62.0	3.0
Standard Deviation	1.3	1.5	2.4	2.0	1.9	1.6	3.1	2.6	2.1	2.5	21.0	1.2
Range	5-9	5-10	1-8	5-10	5-10	5-10	1-10	2-10	3-10	3-10	35-85	2.4-6

NT (n=26)	Average Scores for NT Group (based on Pre-survey)											
	Line / Markmaking	Time / Dedication	Proportion / Perspective	Balance / Uniformity	Use of Color / Value	B/W Shading	Ambition	Craft / Techniques	Experimentation	Concept / Overall Design	Total CW	per-ISE score
Average Score	5.5	6.2	3.3	7.5	6.1	6.1	5.6	5.5	6.7	6.8	59.3	4.2
Median Score	5.0	6.0	3.0	7.0	6.0	5.0	6.0	6.0	7.0	7.0	58.0	4.1
Standard Deviation	0.9	1.4	2.2	1.9	1.7	1.5	2.5	2.6	1.8	2.2	18.8	0.7
Range	3-7	3-10	1-7	5-10	0-9	5-10	2-10	1-10	3-10	3-10	35-85	2.8-5.8

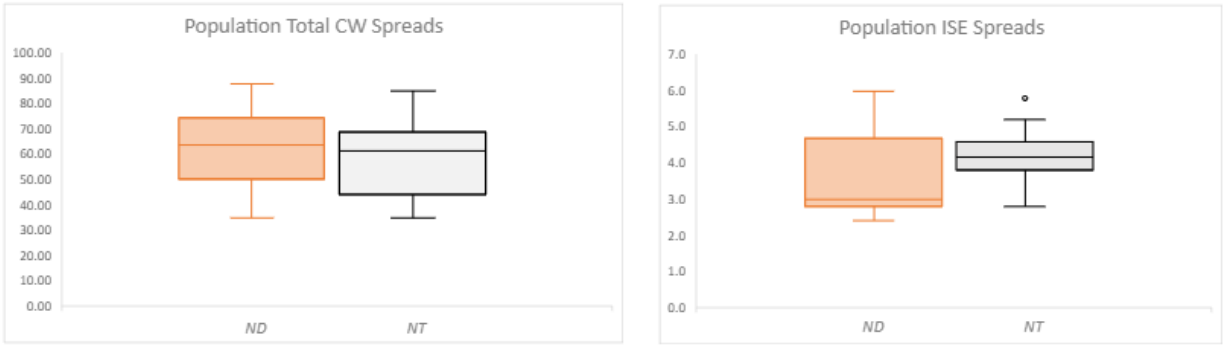

Figure 2. Box and whisker plots of ND and NT groups of students (from left to right total Creative Work (CW) scores and Individual Self-Efficacy (ISE) scores).

Separating the students who self-identified as Maybe ND (n=5) from those who said they were ND (n=6) shows the Maybe ND group clustered at the higher total CW scores (Figure 3), but the results were not statistically significant (t-test p-value 0.42). Sub-category scores among the three groups are shown in Table 2. The Maybe ND group particularly excelled at the subcategories of balance/uniformity, use of color/value, and black/white shading.

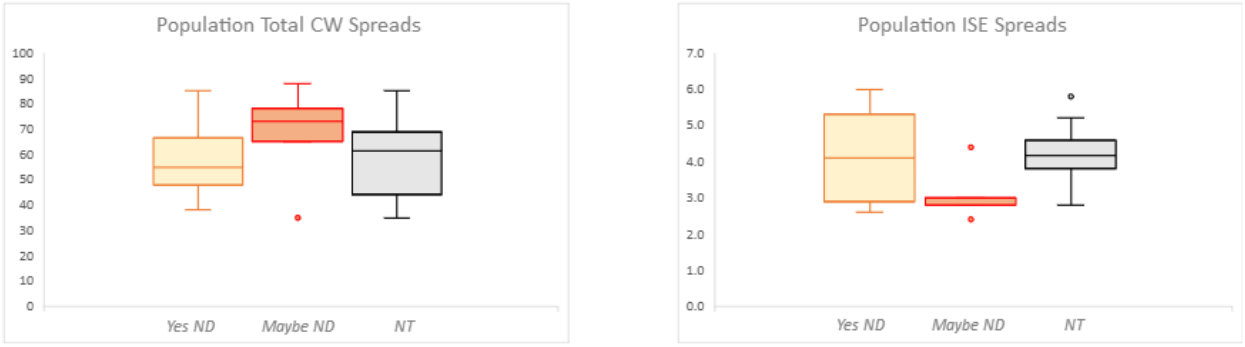

Figure 3. Box and whisker plots of Yes ND, Maybe ND, and NT groups of students (from left to right total Creative Work (CW) scores and Individual Self-Efficacy (ISE) scores).

Table 2: A heat map of the highest and lowest scores in each sub-category between Yes ND, Maybe ND, and NT groups of students (average sub-category scores).

		Average Scores Based on ND ID (based on the Pre-survey)											
n	ND ID	Line / Markmaking	Time / Dedication	Proportion / Perspective	Balance / Uniformity	Use of Color / Value	B/W Shading	Ambition	Craft / Techniques	Experimentation	Concept / Overall Design	Total CW	pre-ISE score
26	NT	5.5	6.2	3.3	7.5	6.1	6.1	5.6	5.5	6.7	6.8	59.3	4.2
5	Maybe	6.0	6.6	4.2	8.2	7.8	7.2	6.6	7.0	6.6	7.6	67.8	3.1
6	Yes	6.0	6.2	3.8	6.3	6.0	5.5	5.2	5.7	6.8	6.7	58.2	4.2

RQ2. Are there similarities or differences among the Innovation Self-Efficacy (ISE) of ND and NT engineering students?

Figure 2 compares the ISE scores among the students. The NT population average ISE score (4.2) was 0.5 points higher than the NDs (3.7). However, these differences are not statistically significant. Separating the Maybe ND students (Figure 3) shows they have a lower average ISE score (3.1) than the NT students. This difference is statistically significant (t-test p-value 0.03).

RQ3. Are there similarities or differences among correlations between ISE and CW for ND and NT engineering students

The individual scores revealed a roughly inverse relationship between ISE and CW. Correlation coefficients were calculated between the ISE scores and total CW scores for the entire sample and each group. Across the 37 students, there was a weakly negative correlation that was marginally significant (Pearson correlation –0.299, 2-tailed sig. 0.072; nonparametric Spearman rho –0.289, 2-tailed sig. 0.082). With the smaller numbers in the sub-types the results were not statistically significant. The NT population displays an insignificant negative correlation (Pearson -0.23, 2-tailed sig. 0.255; Spearman rho –0.25, 2-tailed sig. 0.223). Within the small Maybe ND dataset, weak negative correlations were not statistically significant (Pearson –0.15, 2-tailed sig. 0.811; Spearman rho –0.308, 2-tailed sig. 0.614). The small yes ND group was also not significantly correlated (Pearson –0.395, 2-tailed sig. 0.439; Spearman rho –0.257, 2-tailed sig. 0.623). Given the small dataset, the weak negative correlations appear similar.

Discussion

Overall, the results did not find significant differences in the creativity evident within students' self-portrait "monster" drawings between neurotypical students and those who identified as neurodivergent or maybe neurodivergent. However, the results suggest that the Maybe ND group tended to have higher creativity in their drawings (a larger dataset is needed to verify statistically). The Maybe ND group had lower innovation self-efficacy than the neurotypical or yes ND students. The Maybe ND group likely includes individuals who have not received a formal diagnosis of a condition such as ADHD. Four of the 5 Maybe ND students wrote in ADHD. Without a diagnosis, these students are unlikely to be under medical or receiving medication, which is often used to treat ADHD. The reasons for the lack of diagnosis may be related to cost or the different symptoms that present for some groups (e.g., females).

Previous research has linked ADHD symptoms to low math confidence and literacy skills in college students [10]. They found no direct relationship between attention symptoms and math performance. But there was a relationship between confidence and performance. There were also links between ADHD symptoms and anxiety, and anxiety related to one of the 3 math performance measures. These results reveal interesting findings that could be more generally applicable in settings such as engineering.

It is interesting to consider the different ways that creativity and innovation can manifest among students. Different types of creativity and innovation skills may be relevant within different contexts in engineering. It is unclear to what extent students have accurate perceptions of their own creativity or innovation. The low innovation self-efficacy among some students may not be a true reflection of their actual innovation abilities.

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