Research Articles and Essays

Neuroscience for Neurodiverse Learners:

Lessons Learned about Engaging All Students

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Abstract

The *Neuroscience for Neurodiverse Learners* program provides hands-on experiences and resources to high school and early postsecondary students identified as neurodivergent learners. This article shares lessons learned that can benefit educators seeking to engage neurodivergent learners in the classroom and includes summary results from the NNL summer program.

Keywords: neurodivergent, disability, STEM

Neuroscience for Neurodiverse Learners:

Lessons Learned about Engaging All Students

The University of Washington (UW) received funding from the National Science Foundation (NSF) Innovative Technology Experiences for Students and Teachers (ITEST) program for a project called *Neuroscience for Neurodiverse Learners (NNL). NNL* provides hands-on experiences in the field of neuroscience, networking opportunities, and resources to high school and early postsecondary students identified as "neurodivergent" learners—those with academic challenges related to conditions such as dyspraxia, dyslexia, attention deficit hyperactivity disorder, dyscalculia, autism spectrum disorder, and Tourette syndrome. The project also disseminates findings to teachers of neuroscience and related courses, and, more broadly, to science, technology, engineering, and mathematics (STEM) teachers.

The project is led through a collaborative effort between the UW Disabilities, Opportunities, Internetworking, and Technology (DO-IT) Center and the UW Center for Neurotechnology (CNT). DO-IT has a 30-year history of helping empower students with disabilities to pursue challenging academics and careers. The CNT is one of several Engineering Research Centers across the country, originally funded by the National Science Foundation. This article shares lessons learned through the continuing DO-IT and CNT partnership, building on previous work (Bellman, et al., 2018).

Grounded in theory and research, the *NNL* project takes a student-centered approach that embraces cutting-edge neuroscience, the social model of disability, social justice education, disability as a diversity issue, universal design, and a multi-faceted view of student engagement and retention. The project seeks to achieve the following two goals:

1. College-capable neurodivergent students, through engagement in neuroscience experiences, will gain knowledge about and interest in challenging STEM fields. They will practice communication skills (e.g., for scientific presentations, communication with faculty about disability-related accommodations, and job interviews) that will prepare them for college and careers.
2. Educators and other stakeholders will develop or enhance strategies for teaching neurodivergent learners (e.g., universal design, academic accommodations) and engage in activities designed to encourage neurodivergent learners to participate in STEM fields.

Project strategies include hands-on and technology-rich activities, team-building, problem-solving, communities of engagement, and mentoring activities for neurodivergent students; professional development for educators; and resources for multiple stakeholders. *NNL* applies lessons learned in earlier DO-IT efforts to develop and implement engaging, intrinsically motivating, potentially transformative content that will increase the knowledge and skills of neurodivergent students and ultimately build capacity within formal and informal academic settings to motivate these students to pursue neuroscience and, more broadly, STEM fields. This article focuses on lessons learned from working with neurodivergent students and shares preliminary evaluation outcomes regarding students. These data were presented previously at the 2024 Pacific Rim International Conference on Disability and Diversity.

Frameworks

Traditional efforts to assist individuals with disabilities embrace a "medical model" of disability that focus on the "deficit" of the individual and how the person can be rehabilitated or accommodated so that he or she can fit into an established environment

(Loewen & Pollard, 2010; Moriarty, 2007). In contrast, the "social model" of disability and other integrated approaches within the field of disability studies (DePoy & Gibson, 2008a, b; Gabel & Peters, 2010), consider variations in abilities—like those with respect to gender, race, and ethnicity—to be a natural part of the human experience and suggest that products and environments should be designed in ways that make them welcoming and accessible to everyone. The *NNL* project creates, tests, and disseminates activities and products that are aligned with the social justice model of disability, social justice education, disability as a diversity issue, the characteristics and needs of neurodivergent learners, and universal design. Universal design (UD)—defined as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design"—is an approach that is consistent with the social justice model of disability and has the potential to reduce the need for individual accommodations (Center for Universal Design, 1997; Burgstahler, 2011, 2015). UD challenges society to construct a world where everyone can participate with maximum independence (Loewen & Pollard, 2010). Social justice education is an educational philosophy committed to equity and social change, with its goals clustering around social responsibility, student empowerment, and equitable distribution of resources (Loewen & Pollard, 2010).

Identified Needs

To fill increasing numbers of positions in STEM fields and develop a more robust STEM workforce (CEOSE, 2011; Hecher, 2005; Office of Science and Technology Policy, 2006), the US must draw from a talent pool that includes all demographic groups, including those with disabilities(AAAS, 2001; Congressional Commission…, 2000). Although increasing numbers of individuals with disabilities are attending college, at times they experience less academic and career success than other students (National Council…, 2000;

NSF, 2023b; Office of Disability Employment Policy, 2001).

High-tech careers are possible for individuals with disabilities, including neurodivergent learners, due in part to advancements in assistive technologies that provide access to information technology (IT). The success stories of the relatively few individuals with disabilities who are in STEM fields demonstrate the potential that these individuals have to contribute significantly to STEM disciplines (Bellman & Burgstahler, 2016; Dreyfus, 2009; Helft, 2009; Misner, et al., 1995). Diversity in STEM fields is beneficial not only to specific underrepresented groups, but to the fields themselves. Teams of professionals composed of individuals with diverse skills, experiences, and perspectives are better able to identify multiple ways to solve problems (Beck & Andres, 2005; Hazzan & Dubinsky, 2006; Taylor & Ladner, 2011), thus promoting NSF's mandate to support "the best ideas from the most capable researchers and educators, now and in the future" (Congressional Commission…, 2000). Efforts should be made to increase participation in STEM by citizens with disabilities since, according to NSF, underrepresentation causes a loss of opportunity for individuals, a loss of talent to the workforce, and a loss of diverse perspectives and creativity that are needed to shape the future of technology (NSF, 2023a). Technology companies have recognized the capacity of neurodivergent individuals, especially those with autism spectrum disorder, to contribute to their mission, yet report difficulties in recruiting work-ready job applicants with neurodiversity (Ladner, 2016). Many companies, including Microsoft (n.d.), SAP (n.d.), SAS (n.d.), DXC Technology (n.d.), have undertaken programs to recruit neurodivergent employees.

Additionally, there is a need for science curriculum that is exciting for a diverse audience. Some students do not pursue STEM disciplines because they have not been encouraged to do so, they are not motivated by the content, they are unaware of the broad

range of careers in STEM fields, they lack role models and mentors in these fields, or they expect careers in these areas to be boring and/or unrewarding (Gupta & Houtz, 2000; Jacobs & Simpkins, 2006; Kerry, 2013; Kiernan, 2000; Thomas, 2004; Yardi & Bruckman, 2007). For example, a significant disconnect has been observed between the perceptions of precollege students (who perceive computing careers as "boring, solitary, and lacking real-world context") and those of graduate students in computing (who consider their research "exciting, social, and having a direct and meaningful impact on the world around them;" Yardi & Bruckman, 2007), Students who experience intrinsic motivation in academic areas tend to be more interested in pursuing them (Amabile, 2002). To draw women into STEM fields, it has been recommended that they be shown how work in these fields improves the lives of others (Cohoon, 2007). Leaders in the DO-IT Center have made observations that suggest this is true of neurodivergent students as well.

Researchers at the CNT are leaders in fields of neural engineering, computational analysis, brain-computer interfaces, implantable technology, wireless power, and other exciting innovations that have the potential to improve the lives of individuals who have been injured through accidents, stroke, or disease. Experiences engaging with educators and students have led the *NNL* leadership team to believe that projects, activities, and opportunities that include exposure to these exciting research areas are highly motivating for students, including those with disabilities.

Methods: Key Interventions for Students

During the NNL program, student participants engage in a multi-day Neuroscience Summer Study program. In 2020 and 2021, activities were conducted online due to the COVID-19 pandemic. In 2022 and 2023, activities took place both online and on the UW

campus. Activities included hands-on, inquiry-based activities and cooperative learning. Students participated in neuroscience activities as well as activities designed to practice skill building related to challenges faced by neurodivergent students. More advanced neurodivergent college students acted as mentors, providing support and encouragement to younger students as they progress in academics and toward careers.

Throughout the year, neurodivergent students participated in online and on-campus sessions designed to further promote STEM interest and college readiness. Sessions provided opportunities to practice skills and share strategies for managing challenges. They participated in electronic mentoring, where they learned about neuroscience, informal science learning opportunities, college preparation, and related topics.

All students were offered 1-to-1 mentoring opportunities designed to help them address challenges related to attention, organization, time management, listening skills, and sensory perception. Many sessions included the involvement of a neurodivergent peer-mentor.

Lessons Learned About Engaging Neurodivergent Students

Through conversations with students, observations during *NNL* activities, and engagement with other professionals serving neurodivergent students, project staff identified ten promising practices for engaging students [Table 1] which were presented at the 2024 Pacific Rim International Conference on Disability and Diversity. The lessons will be shared in two new publications of the DO-IT Center called *Tips for Engaging Neurodivergent Students in K-12 Classrooms* and *Tips for Engaging Neurodivergent Students on Postsecondary Campuses* (in press-a, -b) The practices fall broadly within three categories: preparing students, student engagement, and flexibility.

Table 1

Lessons Learned about Engaging Neurodivergent Students

	Lesson Learned	Category
1	Share "what we're doing and why it's important"	Student Engagement
2	Find ways to incorporate humor	Student Engagement
3	Be genuine and be vulnerable at times	Student Engagement
4	Build and share social narratives	Preparing Students
5	Allow for hands-on learning	Student Engagement
6	Encourage student teaching of others	Student Engagement
7	Offer options to students	Flexibility
8	Allow for student-driven content	Flexibility
9	Utilize near-peer leaders	Student Engagement
10	Be aware of assistive technology	Preparing Students
11	Focus on student strengths	Preparing Students
12	Explore coaching for executive functioning skills	Student Engagement

Share "What We're Doing and Why It's Important"

At the beginning of each classroom session, *NNL* instructors make efforts to share the reasons they selected the content and the method of instruction, tying the content to broader goals of the course. This practice was adopted from emerging concepts within the Transparency in Learning and Teaching (TILT) model of academic engagement. The TILT

model employs a set of teaching strategies that focuses on making transparent to students how and why they are learning content in particular ways. TILT's goal is to provide more concrete support for student success, and encourages faculty to be transparent about their course and assignment design choices to provide answers to questions students might have about their coursework such as: 1) *Why am I learning this information – how will it help me achieve course goals in this course, future courses, or future careers?* 2) *What is the specific task I'm being asked to do? What steps should I follow?* 3) *How will this doing this activity help me learn or understand course content better?* 4) *What criteria will the instructor use to evaluate my work?* (Indiana University Bloomington, n.d.)

Find Ways to Incorporate Humor

While it is often said that neurodivergent students, especially those on the autism spectrum, have difficulty understanding humor, NNL staff observed that the use of humor is particularly engaging to students. Project staff have observed that nearly all neurodivergent students in the program appreciated the use of humor in the classroom, even when such experiences were challenging to them. When staff asked students for advice about using humor, three themes emerged. First, students said it is helpful for an individual to explicitly state they are joking and explain the joke after telling it. Those with longer processing times or a more concrete style of thinking said this practice helps them follow the humor and decreases confusion. Second, students said it helps to check in with them about the various humor being utilized in the classroom. The most common concern heard from students was "Sometimes I just want to know people aren't laughing at me." Third, it was observed by staff that using humor over email or other text-based platforms is more challenging as compared to in person. Over text-based platforms, jokes are more difficult to explain, checking in with students is more difficult, and contextual cues such as body language and

facial expression are absent.

Be Genuine and Be Vulnerable at Times

Project staff have observed that neurodivergent students in the program appreciate it when instructors and staff share their "authentic selves" and show vulnerability. On the first day of class, for example, one instructor shared "I am over 50 years old, and it's still a challenge for me to meet new people and make new friends. I've learned some strategies along the way but it's still hard for me. If you have a hard time with these things, just know that there are others here with similar challenges." When one student talked about outside noises making it hard for them to learn, a mentor in the program shared "Yes! Me too. There is so much distraction outside today and I'm having a hard time staying focused. I think I understand what you're saying."

Build and Share Social Narratives

A social narrative, also known as a social story, is a "specially written story that explains a social situation to a student. The emphasis is on describing the situation so that the student can better understanding events as well as the potential thoughts, feelings and actions of other people. Most social narratives also provide the student with information about what they can do in the situation" (Queensland Government, 2022) Project staff provide an online orientation to the campus and classroom activities, including the types of activities to be engaged in, images of buildings and spaces to be visited, anticipated sensory experiences (e.g., the odor in the brain dissection lab, things you can see and hear from the main classroom). For educators interested in more detailed examples of social narratives, the Museum, Arts, and Culture Access Consortium (MAC) maintains a collection of examples on their website (n.d.).

Allow for Hands-On Learning

NNL project staff observed that students were especially engaged during hands-on learning activities, such as the dissection of a sheep brain, the construction of a brain model "brain hat," neuroscience demonstrations with graduate students, the creation of sound-makers from everyday objects, and creating neuron models. The project employed a large number of hands-on learning activities, believing that hands-on learning is highly engaging. By using multiple styles of learning, the brain creates better connections and can store more relevant information. Brain scans also indicate increased activity in motor-related and sensory parts of the brain when thinking about concepts they learned through hands-on experience (Arnholz, 2019).

Encourage Student Teaching of Others

To enhance student learning, one student was offered an opportunity to teach one of the neuroscience classes at *NNL's* Summer Study. Through the development and teaching of a course called "The Neuroscience of Facial Recognition," the student gained confidence in their speaking skills, reinforced their own learning, and acted as a peer mentor to others. Observations from project staff included increased attention from the student group, lively questions, and excitement for the hands-on portion of the class, where students explored the campus in search of items that looked like human faces.

Offer Options to Students

Throughout the *NNL* program, students were offered different options to engage content. For example, prior to the sheep brain dissection activity, students were given the option of a small group learning session outside of the lab, to learn about brain structure on a laptop instead of dissecting a real brain. Students were offered options on where they wanted

to sit in the room, how they might want to respond to questions, and how they might want to control their setting (e.g., a quiet space was close by for students who felt overstimulated and items for fidgeting were placed on tables for students).

Allow for Student-Driven Content

Throughout the *NNL* program, students were offered the opportunity to suggest topics of interest to them. Project staff intentionally left time in the course to build new content based on student suggestions. For example, students said they wanted to learn how meditation impacts the brain, and requested a session exploring how different kinds of music and experiences with music can impact the brain. The most popular class was one suggested by students: the exploration of how neuroscience is portrayed in movies, with an analysis of a movie's accuracy and plausibility.

Utilize Near-Peer Leaders

The NNL program utilizes "near-peer" mentors, defined as mentors who are slightly older than mentees. After completion of a summer study session, for example, students can apply to return as mentors. Undergraduate students who identify as neurodiverse also participate in the program to engage with high school students on college-preparation activities as panelists, provide assistance with lab work, and other skill building. Educators at all levels are encouraged to seek opportunities for near-peer mentoring with their neurodivergent students.

Be aware of Assistive Technology

Educators are encouraged to explore assistive technology (AT) commonly used by neurodivergent learners, especially in the areas of note taking, organizing ideas, reading,

writing, and calendaring (Exceptional Individuals, n.d.). Project staff offered opportunities for students to learn about and try AT in the classroom. For example, three of the four students who tried using smart pens for the first time during the summer study program stated they would continue using the technology during their academic year. A smart pen, in combination with specialized notebook paper, allows the user to record a lecture and synchronize the audio recording to their written notes. Later, when the user is reviewing their written notes, they can easily locate and play back the related audio content.

Focus on Student Strengths

Project staff are encouraged to invest time with students to ask them about their academic and social strengths, and actively encourage students to build on and utilize their strengths in the classroom. *NNL* students learn about "strengths-based" models of viewing disability, which means focusing on what the person can do well, not what they cannot do because of their disability. Students are encouraged to recognize traits related to their disability that make them unique, helping them see that these traits can contribute positively to their identity. Common strengths reported by students in the program included the following:

- Does well in online learning
- Creative thinking and problem solving
- Persistence and dedication
- Empathy skills and kindness
- Strong or detailed memory
- Spatial memory and three-dimensional thinking
- Music and artistic skills

- Honest and direct communication
- Strength in mathematics

Students in the program also learned about historical models of disability such as the "medical model," which has viewed disability as a defect within the individual. In this model, disability is viewed as an unfortunate trait that needs to be "fixed." They are encouraged to consider how various models might impact their identity and experiences.

Explore Coaching for Executive Functioning Skills

Educators are encouraged to explore how they might support the development of executive functioning skills in their disabled students, especially neurodivergent learners (Bellman, et al., 2015). Executive functioning skills typically develop quickly in childhood and during the teen years but keep developing into the mid 20s. Trained "academic coaches" can help students build skills in the areas of paying attention; organizing, planning, and prioritizing; starting tasks and staying focused on them to completion; understanding different points of view; regulating emotions; and self-monitoring (keeping track of what you're doing).

Results

The application process for the *NNL* program was competitive, and applicants had to meet the following criteria to be eligible for consideration:

- Identify as a neurodiverse learner (defined as those with academic challenges related to conditions such as dyspraxia, dyslexia, attention deficit hyperactivity disorder, dyscalculia, autism spectrum disorder, and Tourette syndrome).
- Have aptitude and interest in attending college.
- Currently be a high school sophomore, junior, or senior, or in their first year of

college.

- Have access to a computer and internet connection to use video conferencing tools.

The COVID-19 pandemic had a significant impact on the student activities. Due to the pandemic, project staff were forced to pivot many activities that were planned to be on-site to virtual environments. As the pandemic and the resulting guidelines regarding in-person events changed every year of the project, the data collected each year cannot be compared directly. No two years were conducted in exactly the same way. Below is a brief summary of each summer program including the number of students who attended and the results from feedback collected from the participants at the end of each summer study program.

The first summer study program was originally planned to be a 10-day in-person event. Due to the pandemic, the program shifted to a virtual environment composed of a 5-day online summer program and fourteen online events during the academic year. The program included seven educational sessions about neuroscience and ten sessions related to communication, college preparation, mentoring, and leadership. Twenty-one students participated in the first summer study program experience. Ten of these students went on to engage in additional year-round activities, along with students new to the program.

At the end of the first summer study program in 2020, students were asked to choose from a list of skills they felt more confident and/or increased competency in as a result of the camp experience. The results were as follows:

- 41.18% chose Initiating or participating in conversations
- 52.94% chose Interacting with other people appropriately
- 52.94% chose Requesting modifications to the environment/class
- 70.59% chose Managing my time and my schedule

- 47.06% chose Focusing attention and listening to others
- 58.82% chose Requesting disability-related accommodations
- 52.94% chose Using technology
- 82.35% chose Talking about my challenges

Due to the continued pandemic, the second summer program was composed of a ten-day online program. Seventeen students participated, along with five returning mentors from the first summer study. The summer program included fourteen educational sessions about neuroscience and eighteen sessions related to communication, college preparation, mentoring, social skill-building, and leadership. Seven of these students went on to engage in additional year-round activities. At the end of the second summer study program students were asked to choose from a list of skills all those they felt more confident and/or increased competency in as a result of the experience. Results:

- 38.46% chose Initiating or participating in conversations
- 30.77% chose Interacting with other people appropriately
- 61.54% chose Requesting modifications to the environment/class
- 76.92% chose Managing my time and my schedule
- 61.54% chose Focusing attention and listening to others
- 69.23% chose Requesting disability-related accommodations
- 61.54% chose Using technology
- 69.23% chose Talking about my challenges

As concerns regarding the pandemic continued to persist, the third summer study program was held in a hybrid format composed of six days of online activities and four days of activities on campus. Eighteen students participated, along with three returning mentors from previous summer camps and activities. The summer program included twelve

educational sessions about neuroscience and twelve sessions related to communication, college preparation, mentoring, social skill-building, and leadership. Fifteen of these students went on to engage in additional year-round activities. At the end of the third summer study program students were asked to choose from a list of skills all those they felt more confident and/or increased competency in as a result of the camp experience. Results:

- 53.8% chose Initiating or participating in conversations
- 46.2% chose Interacting with other people appropriately
- 69.2% chose Requesting modifications to the environment/class
- 61.5% chose Managing my time and my schedule
- 46.2% chose Focusing attention and listening to others
- 38.5% chose Requesting disability-related accommodations
- 69.2% chose Using technology
- 53.8% chose Talking about my challenges

The fourth summer study program was composed of five days of online activities and five days of on-campus activities. Twenty-six students participated in this summer study program along with one returning mentor from previous summer camps and activities. The summer program included eleven educational sessions about neuroscience and seven sessions related to communication, college preparation, mentoring, social skill-building, and leadership. Thirteen summer study program students engaged in additional year-round activities. At the end of the fourth summer study program students were asked to choose from a list of skills all those they felt more confident and/or increased competency in as a result of the camp experience. Results:

- 66.7% chose Initiating or participating in conversations

- 66.7% chose Interacting with other people appropriately
- 75% chose Requesting modifications to the environment/class
- 50% chose Managing my time and my schedule
- 41.7% chose Focusing attention and listening to others
- 66.7% chose Requesting disability-related accommodations
- 50% chose Using technology
- 41.7% chose Talking about my challenges

Discussion

Educators seeking to effectively engage neurodivergent students can benefit from the lessons learned during the *NNL* project implementation. Most of the lessons came about as the result of direct conversations and interactions with students, helping ensure that their voices are centered in the larger conversation about serving neurodivergent students. The data shared in this article are limited to a sample that project staff have been collecting. With the small sample size for each cohort, it was decided that evaluators would need several full years of data prior to engaging in a larger complex analysis. Over the next year, the project will analyze these data as well as data collected from student interviews and the repeated surveys that focus on interest in neuroscience and STEM education and career, participation in *NNL* activities, growth in skills to manage challenges typical of neurodiverse individuals, and confidence in ability to succeed in a STEM career to explore the relationships between independent variables, outcome variables, and mediating variables.

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