Board 415: Transforming Engineering Education for Neurodiversity: Epistemic Communities as a Model for Change

Dr. Maria Chrysochoou, University of Connecticut

Maria (Marisa) Chrysochoou is a Professor and Head of the Department of Civil and Environmental Engineering at the University of Connecticut.

Dr. Arash Esmaili Zaghi P.E., University of Connecticut

Arash E. Zaghi is an Associate Professor in the Department of Civil and Environmental Engineering at the University of Connecticut. He received his PhD in 2009 from the University of Nevada, Reno, and continued there as a Research Scientist. His latest

Ms. Connie Mosher Syharat, University of Connecticut

Connie Mosher Syharat is a Ph.D. student in Curriculum and Instruction and a Research Assistant at the University of Connecticut as a part of two neurodiversity-centered NSF-funded projects, Revolutionizing Engineering Departments (NSF:RED) "Beyond Accommodation: Leveraging Neurodiversity for Engineering Innovation" and Innovations in Graduate Education (NSF:IGE) Encouraging the Participation of Neurodiverse Students in STEM Graduate Programs to Radically Enhance the Creativity of the Professional Workforce". In her time at the University of Connecticut she has also has served as Program Assistant for an summer program in engineering for middle school students with ADHD. Previously, she spent eight years as a K-12 teacher in Connecticut, where she maintained a focus on providing a varied learning environment and differentiated instruction for all types of learners. She received her Master's Degree in Modern Languages from Central Connecticut State University in 2011. She earned her Bachelor of Arts in Hispanic Studies and her teaching certificate from Connecticut College in 2001. She is currently pursuing a doctoral degree in Curriculum and Instruction at UConn's Neag School of Education.

Todd Campbell, University of Connecticut

Todd Campbell is a Professor and Head of the Department of Curriculum and Instruction at the University of Connecticut.

Transforming Engineering Education for Neurodiversity: Epistemic Communities as Infrastructure for Change

Abstract

A growing body of literature suggests that neurodiverse learners, including students with autism, ADHD, and dyslexia, may possess strengths that are highly desirable within engineering disciplines, such as systems thinking, creativity, and 3D visualization skills. However, despite the potential of neurodiverse individuals to leverage these assets to contribute to innovative solutions to engineering problems, they remain highly underrepresented in engineering majors. With this in mind, a department-level initiative was established to radically transform the educational experiences of neurodiverse students by moving beyond academic accommodation of learning differences to empowering students to leverage their unique strengths in engineering. In undertaking this transformation, an epistemic communities model was adopted and implemented as infrastructure for change as part of a National Science Foundation Revolutionizing Engineering Departments (NSF:RED) grant within the context of a Civil and Environmental Engineering department at a large, research intensive (R1) institution. Epistemic communities unite members in a shared purpose through the establishment and transmission of shared values and practices, allowing stakeholders to build community from within and sustain lasting change. Through our epistemic community, we aim to make local change within the department, but we also hope to contribute to a broader paradigm shift that transforms how university faculty and staff understand and perceive neurodiversity, a key lever for enhancing the educational experiences of neurodiverse students. This conceptual paper presents an overview of these departmental transformation efforts, with a focus on the shared theory, code, and tools around which our epistemic community is constructed. First, we present a social ecology theoretical framework (theory) that challenges the deficit-based approach that has historically shaped neurodiverse learners' experiences by emphasizing learners' assets and their potential of a neurodiverse student body to contribute to innovation for the benefit of society. Second, we discuss the infusion of strengths-based language (code) related to neurodiversity and its role in contributing to a collective mind shift across the department. Third, we present a discussion of the practices, structures, and artefacts (tools), such as shared standards for course revision, that were established and co-created by community members to facilitate departmental change.

Introduction

The current educational system more broadly defines neurological differences as a disability, dysfunction or disorder, creating a perceived stigma for non-traditional ways of thinking and learning. Consistent with this framing, educational programs are designed for neurological similarities at the expense of the neurologically diverse. In the field of engineering, more specifically, programs are often characterized by their narrow focus on and rigid adherence to standardized ways of thinking and traditional modes of instruction and assessment [1, 2]. This one-size-fits-all model of teaching and learning limits opportunities not only for traditional learners to engage in interactive learning and creative problem solving but also for students whose ways of thinking fall outside of the typical range. While accommodations such as extended time on exams and assistance with notetaking may provide some form of equity for these students [3-5], they fail to address the underlying mismatch between the unique abilities of neurodivergent students and the demands of the traditional educational environment [3]. As it stands, the current system does very little to acknowledge the strengths of non-traditional learners [3, 6].

Given this, in this conceptual paper, we detail how our work has committed to identifying and systematically dismantling the cultural and institutional impediments to inclusive engineering education, widening access and producing a more cognitively diverse engineering workforce. In undertaking this transformation of a Civil and Environmental Engineering Department, that serves as the context of our work, we pursue cultural change in a risk-averse and change-resistant engineering field through the lens of epistemic communities, a paradigm that focuses on community building from within, instead of a top-down approach. Through this paper that details our work, we aim to advance knowledge about the strengths of neurodiverse students and the types of effective strategies that can capitalize on neurodiverse students' strengths for engineering applications. To accomplish this, we reveal how framing the iterative and ongoing work of an engineering department as an epistemic community created the infrastructure for change needed to move from framing neurodiversity as disability to framing it as an asset in ways that promote inclusive, effective academic strategies through an expanded definition of diversity. This framing, as detailed throughout the rest of this paper, has supported the department's early transformational efforts as it seeks to reimagine engineering education as an inclusive and thriving space for neurodiverse learners.

Theoretical Framework and Literature Review

Neurodiversity and Engineering Learning Contexts

Neurodiversity is a crucial aspect of human diversity, referring to the wide range of ways in which our brains function, think, learn, and process information. It encompasses a spectrum of neurological variations, such as autism, ADHD, dyslexia, and Tourette syndrome, among others [7]. These natural variations can bring both unique challenges and strengths in different contexts and learning environments. In the field of engineering, collaborative efforts between individuals with diverse cognitive abilities lead to creative and holistic solutions for complex challenges facing our nation, such as cybersecurity, climate change, and aging infrastructure [8]. The level of complexity of these problems demands participation and contribution of a wide spectrum of perspectives, lived experiences, and cognitive skills.

To foster a more inclusive and diverse engineering field, it is crucial that the way in which engineering education approaches neurodiversity evolves to align with the needs of the profession. By shifting away from a deficit-based view and a one-size-fits-all approach, and instead embracing neurodiversity as an asset, future engineering graduates will be better equipped to foster a positive and inclusive work environment [9]. The current approach to neurodiversity in education, which defines neurological diversity primarily as a disability and overfocuses on student deficits at the expense of cultivating student strengths, is causing significant challenges for the recruitment and retention of non-traditional learners [8]. This approach and the associated stigma related to disability labels has been linked to an increased prevalence of mental health challenges including anxiety, depression, and burnout within this population [10-13]. We suggest that to address this, the focus of engineering education must shift from individual to collaborative problem-solving, creating a safe space for students of diverse cognitive abilities to collaborate and bring their unique skills to the table that concurrently enhancing students' sense of belonging and inclusion. For a team-based engineering project as part of the historical focus on individual problem solving, it is traditionally expected that every team member strives toward excellence in all skills involved in the project, such as writing, oral presentation, and analysis. However, in the collaborative problem-solving paradigm, there is a general understanding that students can contribute to projects in a way that is more tailored to their skills and interests. By promoting this approach, a culture of collaboration, innovation and inclusion in engineering education and the profession is fostered. This shift in focus should also include flexible teaching and evaluation methods that recognize that different students learn differently [14].

A Theory of Change for an Engineering Department

The NSF Revolutionizing Engineering Departments (RED) program mandates, as the name implies, department-wide transformation and adoption of the proposed educational interventions as part of the culture. As such, a key component of a RED project is to adopt a theory of change, which is, ideally, an articulation of how the proposed activities will lead to the desired outcome in the project, informed by one or more change theories [15]. A key difference between the terms "change theory" and "theory of change", as articulated by these authors, is that the former is a theoretical framework for how change occurs, while the latter is a living document that is revised as the project progresses. A theory of change according to this definition encompasses the following components: context, outcomes, indicators, interventions and assumptions.

During the proposal preparation, the team identified the desired outcome as *increasing the number of neurodiverse individuals in the engineering workforce*, with the rationale that increasing the cognitive diversity will increase creativity and innovation in the field. This idea rests on the theoretical underpinning of the neurodiversity movement that views neurodiversity from an ecological perspective [16]. While we will elaborate on the theory in the next section, we allude to it here as a fundamental assumption to build our Theory of Change for the project: adoption of interventions for lasting change must be a result of buy-in to the fundamental theoretical framework (Figure 1).

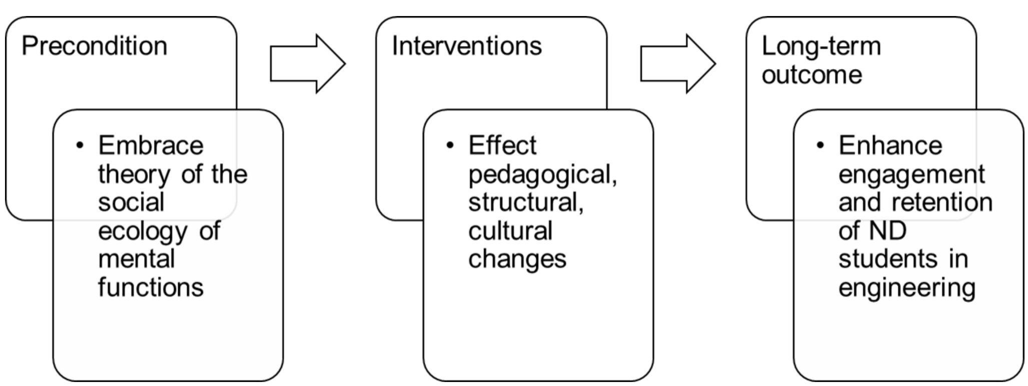

Figure 1: Theory of Change diagram for INCLUDE project (after Reinholz and Andrews, 2021)

During the proposal preparation, the team also interacted with several stakeholders across the university and realized that the reach of the project could extend beyond the department in terms of adoption of the theoretical stance of the project and also with respect to academic policies and practices. While RED projects have a focus on the department as unit for change, the program as a whole has a mandate for broader change of engineering education; thus, extending the theory of change to encompass a broader spectrum of stakeholders within the university is appropriate and even desirable. A criterion to shape the Theory of Change for the INCLUDE project was therefore flexibility in terms of extending to a larger number of actors with different roles within higher education.

Thus, there are two distinct aspects in terms of institutional change: the process of individuals embracing the ecological model of neurodiversity undergoing a fundamentally psychological transformation, and the implementation of a framework or infrastructure to translate this new theoretical lens to practice with a scope reaching beyond the department. Accordingly, the INCLUDE team adopted two interrelated theories to build the Theory of Change for the project: epistemic community theory and Jung’s concept of collective unconscious. Epistemic community theory and Jung's concept of collective unconscious are both related to the idea of shared understanding or knowledge within a group of people. However, they come from different fields of study and have different focuses. Epistemic community theory is a concept in international relations that refers to a group of experts who share a common understanding of a particular issue and work together to influence policy decisions [17]. Jung's collective unconscious is a psychological concept that refers to the shared beliefs and experiences that shape the culture and behavior of a group of people [18]. While both relate to collective understanding, the scope and focus are different.

Epistemic community theory can be used to understand how a group of experts come together to shape policy decisions on a particular issue, while Jung's concept of collective unconscious can be used to understand the cultural and psychological factors that influence the beliefs and experiences of the individuals within that group. Epistemic community theory can be used to understand how experts in the field of neurodiversity come together to shape policy decisions and create a shared understanding of the strengths and abilities of neurodiverse individuals. This can lead to more inclusive policies and practices within organizations and society as a whole. Jung's concept of collective unconscious can be used to understand how cultural and psychological factors shape societal beliefs and experiences related to neurodiversity. For example, by understanding how societal beliefs about intelligence and ability can shape perceptions of neurodiversity, it is possible to identify and challenge these beliefs to create a more inclusive society. By integrating these two perspectives, it is possible to gain a more complete understanding of how shared knowledge and beliefs shape societal attitudes and practices related to neurodiversity. This can help to create a strength-based mindset that recognizes the unique abilities and contributions of neurodiverse individuals and works to include them in all aspects of society.

In summary, Epistemic community theory can provide the technical understanding of neurodiversity while the collective unconscious can provide the cultural and psychological understanding of societal attitudes and perceptions. Together they can provide a framework for promoting inclusion and acceptance of neurodiverse individuals. This paper focuses on the

INCLUDE project approach in creating an epistemic community around neurodiversity within the department and beyond.

A Civil and Environmental Engineering Department as a Context for Understanding Epistemic Communities as Infrastructure for Change

The Civil and Environmental Engineering Department where this transformational work was initiated is within a School of Engineering at an R1, research intensive, university that offers fourteen engineering majors and is in the New England region of the United States. More broadly at the university, students that identify as neurodivergent may seek support through the Center for Students with Disabilities (CSD) and through Counseling and Mental Health Services. In FY2018, 4,200 undergraduates were registered with CSD, or ~18% of the undergraduate student population; the corresponding percentage in FY15 was 8.1%. Of these, 950 students (22.5%) reported ADHD, 127 (3%) Autism Spectrum Disorder, 508 (12%) cognitive and learning disabilities, while 40% reported psychiatric disabilities (some students report more than one category). The latter group was the fastest increasing category in four consecutive years of data (not publicly available).

Table 1. Students Registered through the Center for Students with Disabilities Fiscal Year 2015 (FY15)

Condition reported	(N) Students
Attention Deficit Hyperactivity Disorder (ADHD)	950 (22.5%)
Autism Spectrum Disorder (ASD)	127 (3%)
Cognitive and Learning Disabilities	508 (12%)
Psychiatric Disabilities	N unavailable (40%)

While there is no discipline-specific data available (even though it will eventually be possible to extract it for the purposes of our research), the percentage of students registered with CSD in CEE courses is approximately 15%, based on instructor feedback. There are about 400 students enrolled in the two CEE programs, which means there may be up to 60 students who have requested support, although this may not be an accurate estimate, given that students are taking multiple courses and may be counted more than once. These numbers do not account for the number of students who do not seek accommodations, and the number of students who do not have self-knowledge about neurodiversity; previous research indicates that only 17% of students who received supports in high school seek accommodation in college [19]. Another study found that only 16.6% of participants who were formally diagnosed with ADHD were receiving services from the university's accessibility office [3]. The number of undiagnosed individuals is unknown. The need to provide a more inclusive, supportive environment for these students at the time this project was initiated was and continues to be more acute than ever. Given this as a context for better understanding where this work reported in this conceptual paper took place, we next articulate the most current version of the reciprocally refining theory, codes, and tools that serve as the infrastructure for the department's ongoing efforts.

Theories, Codes, and Tools for Moving Beyond Accommodations for Neurodiverse Learners

There are three elements in a successful epistemic community: a *theory*, which provides a common stance or purpose for all members; a *code*, a specialized language which the community uses to interact and generate new knowledge; and a set of *tools*, which are the mechanisms to implement and transmit common knowledge both within and across the community [20]. These reciprocally reinforcing elements of the epistemic community are key to interpretations, practice, and communication among practitioners in the community (i.e., faculty members in the Civil and Engineering Department). As Glazer and Peurach [20] note, the limited effectiveness of implementing new methods in educational institutions is that there is a focus on tools and on top-down administrative changes, without the concomitant creation of a common language and values that provide motivation and enable communication. Given that language is a tool for construction of shared knowledge and a means of representing our collective understandings (unconscious) [21], a particular focus was placed into the systematic creation and deployment of a common language within the community. More about each of the three elements of the epistemic community that supports the department's movement beyond accommodations for neurodiverse learners are described in more detail next.

Theory

As a reminder, a theory is an organizing schema that provides a lens for interpreting events and infuses experiences with meaning [20]. The social ecological theoretical framework is the theory identified and adopted as a common interpretative framework in the engineering department. The social ecological theoretical framework provides a lens to support the epistemic community in moving away from the predominant, deficit-based approach toward neurodiversity. This theoretical framework contests medical models of disability that pathologize individuals with diverse cognitive functioning by framing deviations from perceived norms as problematic or a deficit of the individual [22]. Conversely, the social ecological theoretical framework considers populations and cognitive diversity within populations normal and a potential strength for the population that "bestow talents and benefits" [7]. In this, while there is a history of not acknowledging the talents and benefits of neurodiversity within populations, recent asset framing of neurodiversity imagines a more justly represented and talented pool of engineers capable of increased abilities related to neurological diversity. For example, divergent thinking and risk-taking have been recognized as strengths among individuals with ADHD [23-26], 3-dimensional visualization and global thinking have been correlated with dyslexia [27-29], and systems thinking and pattern identification have been identified as strengths among individuals with autism [30, 31].

Code

Within epistemic communities, code represents the language, drawn from theory, that supports epistemic community members in understanding and interpreting experiences. The codes offer community members a common way of communicating about their experiences and observations or for examining or reflecting on their experiences [20]. In the engineering department, a code shift was made possible through the introduction of specific language that framed neurodiversity as an asset; this change in language usage was in stark contrast to previous use of language that reflected a framing of neurological variations as cognitive disorders.

The most important example of the code used within our epistemic community is our use of the term "neurodiversity" rather than the term "disability" to refer to individuals with neurological variations such as ADHD, autism, and dyslexia. This is a dramatic departure from the language used within higher education as a whole, and within the specific context of our university. Up until now, the language of disability has been used to refer to neurological variations that continue to be primarily understood as a set of cognitive impairments or deficits. This language has been widely accepted and propagated through the Diagnostic and Statistical Manual of Mental Disorders, which was first introduced in 1952, and has since been released as a revised version of the fifth edition, the DSM-5-TR. It is important to note that the publishers of the DSM describe the text as "the most comprehensive, current, and critical resource for clinical practice available to today's mental health clinicians and researchers," and state that, "This latest volume offers a common language for clinicians involved in the diagnosis and study of mental disorders" [32]. In essence, the DSM is not simply a diagnostic guide; it is a comprehensive language guide that provides the codes signaling shared understandings held by a community of practitioners. These practitioners employ codes (e.g., symptoms, etiology, disorder) that frame neurological diversity and the associated traits as diseases that warrant intervention and treatment. This deficit-oriented approach to neurological variation is also codified in the U.S. federal law through the Americans with Disabilities Act (ADA) and Section 504 of the Rehabilitation Act of 1973 and embedded in higher education through policies and structures crafted in response to these laws and the broader social and political movements in which individuals with disabilities fought for equal rights and accessible education.

The shift from disability-oriented framework to a neurodiversity-oriented approach that emphasizes strengths rather than weaknesses requires the adoption of new codes that communicate and create new meaning for the users of these codes. Within the following passage, examples of these codes are italicized. Many online resources frame neurological variations as a disorder and use pathologizing language that overemphasizes deficits and fails to acknowledge individual strengths. For example, in many sources, ADHD is encoded as a *disorder* with a laundry list of *deficits* including *inattention*, *hyperactivity*, and *impulsivity*. As ADHD is typically presented as a medical problem within these resources, the language frequently refers to *treatment*, *diagnosis*, and *disability* [33, 34]. Within our epistemic community, we encode ADHD as *neurodiversity*, with a corresponding list of common *traits*, *strengths*, and *challenges.* Strengths such as *divergent thinking* and *risk-taking* are presented as *assets* within engineering. Challenges are acknowledged and are contextually framed as interactions with the traditional educational environment rather than located within the individual. Across all program communications, both strengths and challenges related to neurodiversity are presented, allowing members of the epistemic community to consider the assets that neurodiverse students bring to table rather than focus solely on remediation of student weaknesses or perceived deficiencies. This framing also shifts the conversation from the limited approach of employing academic accommodations to mitigate student weaknesses by encouraging faculty to *build in flexibility*, *encourage self-awareness*, and *empower students to use their strengths* within the educational environment.

In addition to these linguistic codes, visual cues were employed as a way to encode strengths-based messages through non-verbal modes of communication by means of graphics and flyers related to the program activities. Traditional graphics in the engineering department often used straight lines and photographs of professionals in engineering settings; however, non-traditional imagery was adopted to encode our efforts as a dramatic departure from the status quo and establish a non-verbal connection with creativity and non-linear thinking. These visual codes included use of *curved lines*, *flowing shapes*, and *abstract artwork* in relation to neurodiversity, use of *spectrum* imagery (spectra of color for example) to represent a range of neurological profiles/abilities, and *multi-colored mosaics* composed of diverse components working together to form a cohesive image. The use of non-verbal codes to support the creation of meaning around the concept of neurodiversity is well aligned with understandings of neurodiversity in that it makes use of multiple modes of communication and leverages visual thinking abilities that may be strengths for many neurodiverse individuals. With these visual codes, we invited the viewer to consider alternative ways to express ideas within the traditional engineering environment through abstract, intuitive, and creative thinking. An example of visual codes used within outreach activities is provided in Figure 2. In Image A, individual puzzle pieces reflect a view of the uniqueness of each individual such as that found in neurological variations. Meanwhile, in Image B, the unique properties of individual pieces form part of a larger image, evoking the concept of the human ecology approach to neurodiversity.

a) Individual puzzle pieces b) Puzzle pieces together form a larger image.

Figure 2: Example of visual codes used within outreach activities

Other codes contributed to the establishment of the program's identity within the engineering department and university. The letter *i* was significant, as it grew into a sort of quick reference to components of the INCLUDE program. The core group of faculty engaging in professional development and course redesign activities became known as the I-Team. The set of standards that would be developed by this team became known as the I-Standards, and courses that adhered to these standards would be informally labeled I-Courses within the department. The "I" here became a quick code for *i*nclusion of neurodiverse learners while also referring to our aim of personalizing education for *i*ndividual students. This way of referring to courses also mirrored the university's coding for courses aimed at developing competency in written communication (W courses) and quantitative skills (Q courses). It should be noted that our coding of redesigned engineering courses as I-Courses was only implemented within the department, as larger systemic structures and policies at the university related to course naming did not allow our courses to be designated as such in the course catalog.

The infusion of codes representing a range of strengths-based language and symbolic imagery throughout the epistemic community contributed to the development of a collective mind shift about neurodiversity within the department and across the university. This strengths-based language has expanded its reach far beyond the department through our interactions with members of the broader engineering education community and, at times, with collaborators, educators, activists, and other interested parties across the university and around the globe.

Tools

In epistemic communities, tools are artifacts that embody the theory and are infused with codes aimed at the accomplishment of the community's pursuits [20]. In the engineering department, multiple tools were developed to support the adoption of theoretical concepts related to neurodiversity and the implementation of practices within the department to build an inclusive learning environment for neurodiverse students. Within the following section, we will discuss a range of tools that may be described as epistemic objects, structures, and practices; these tools facilitate the exploration, development, and refinement of knowledge within the epistemic community [35]. The tools presented here include a) a department structure called the I-Team; b) a set of standards for inclusive teaching called the I-Standards; c) a list of I-Courses, courses that have been redesigned for inclusion under the guidance of the I-Standards d) campus-wide discussions, workshops, and presentations; and e) a range of multimedia communication tools that employ strengths-based and diversity-oriented codes to share knowledge about neurodiversity and inclusive learning spaces within and beyond the epistemic community. Finally, we will discuss how sharing personal experiences of neurodiversity has emerged as a key practice that forms part of our epistemic community's toolbox. This practice centers the lived experiences of neurodiverse individuals (students, staff, and faculty), invites and builds connections among members of our community, and empowers neurodiverse individuals to be producers of knowledge while also challenging the often deficit-based narrative that is produced and reproduced through scientific research. In the following sections, we detail the tools that were implemented, their use and purpose, and the interactions between members of our epistemic community with these various tools.

I-Team

The I-Team is an example of a departmental scaffold that structures faculty learning through a community of practice and provides time, space, and incentives to explore knowledge related to neurodiversity and develop more inclusive pedagogies. The desired outcomes of this structured learning experience for faculty include the development of a strong awareness of the experiences, strengths, and challenges of neurodiverse engineering students, increased understanding and adoption of inclusive teaching practices, and the implementation of redesigned courses across the curriculum. Team members were provided both financial and time incentives (stipend and teaching release) for their participation in the group activities. The group met bi-weekly, with time for neurodiverse student panels, presentations by experts in teaching and learning on topics such as Universal Design for Learning (UDL) and alternate assessments, and additional time for discussion, reflection, and application of key concepts. Early cohorts of I-Team faculty then became experts who are able to share their experiences and lessons learned with subsequent cohorts.

I-Standards

The I-Standards are a set of shared standards for inclusive courses that were co-created by I-Team members to facilitate departmental change in the realm of teaching and learning. These standards are the result of brainstorming sessions conducted during a summer retreat. The retreat was attended by program leaders, staff, and the first cohort of I-Team faculty. Together, the team drew on prior knowledge and experiences to propose a list of key characteristics of inclusive courses. These standards have been revised multiple times through an iterative process that integrates faculty and student feedback. These standards are anchored in a strengths-based approach and are further divided into three focus areas: 1) Culture of Inclusion, 2) Teaching and Learning, and 3) Communication and Supports.

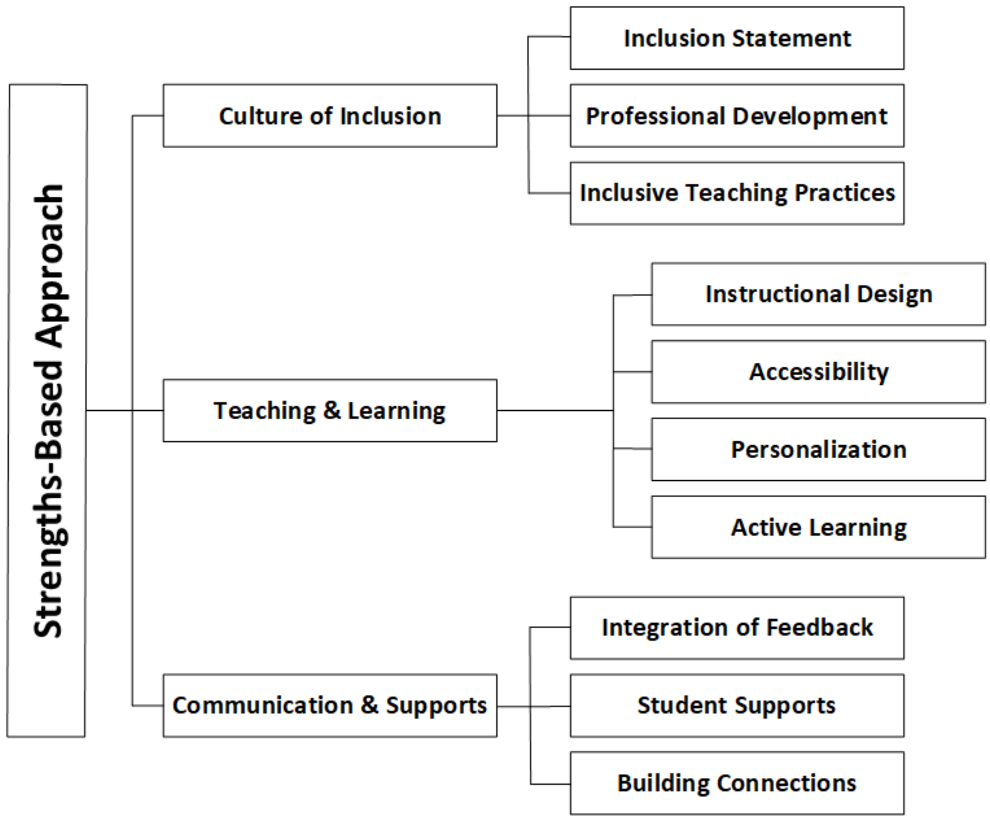

Figure 3. Map of Faculty-Created I-Standards for Inclusive Teaching

Standards related to an inclusive culture guide faculty to provide a personalized inclusion statement as part of their introductory course materials, to participate in professional development related to neurodiversity, and to incorporate inclusive teaching practices. Standards related to teaching and learning guide faculty to incorporate teaching practices the increase accessibility and enhance the ability of a wide range of students to use their strengths within the engineering classroom. These teaching and learning standards emphasize the importance of instructional design, accessible materials, active learning, and personalization of learning through built-in flexibility and student choice. These standards draw on Universal Design for Learning (UDL) principles that encourage instructors to make use of multiple modes of representation, while providing opportunities for multiple modes of engagement, action and expression [14]. Finally, standards related to communication and supports address several needs: 1) the need for students to both receive feedback from instructors about their learning and provide feedback to instructors about their learning experiences; 2) the need to provide scaffolds to support student success; and 3) the need to build connections between peers and faculty to support student learning, wellbeing, and sense of belonging (Figure 3).

I-Courses

The redesigned courses are at once artifacts, practices, and structures. Each redesigned course syllabus exists as a record of and recipe for the reimagined curriculum within the department, while the class itself represents a physical and temporal space in which faculty and students engage through the inclusive practices set forth by the epistemic community standards (I-Standards). The approach to course redesign across the curriculum started with core courses in the sophomore and junior years, given that many efforts to transform engineering education have targeted the first and final years of study. Redesigning core courses, including Mechanics of Materials, Applied Mechanics I (Statics), and Fluid Mechanics, which are required courses in many engineering majors, allows students from departments across the school of engineering to access the transformed curriculum. This structure expands the impact of the course redesign and extends the reach of strengths-based messaging around neurodiversity beyond the Department of Civil and Environmental Engineering. The codes related to neurodiversity are built into each redesigned I-Course through features such as the personalized inclusion statement and a brief presentation that is made either in-person by INCLUDE staff or by video recording. The content of this presentation includes information about neurodiversity through a strengths-based lens and a summary of the theory that drives our practices. Thus, all students who enroll in an I-Course are also introduced to the theory, codes, and tools that guide this epistemic community.

Multimedia Communications

A variety of multimedia communications have functioned as tools to support the development of shared language, understandings, and practices within the epistemic community. Some examples of these multimedia tools are social media platforms such as Instagram and Twitter, a monthly departmental newsletter called "INCLUDE in the classroom," and short videos related to the project and the I-Courses. However, the development of a project website called "Neurodiversity at UConn" serves as the most comprehensive source of information about our strengths-based approach toward neurodiversity, the project, and the work of the I-Team. The website also features a blog that highlights student work and neurodiverse student perspectives of higher education. Together, these contributions may increase awareness of neurodiversity, reduce feelings of isolation among neurodiverse students, and empower students to advocate for themselves within the higher education environment. This website is still evolving as we seek to improve the quantity and quality of the information provided there.

Sharing Personal Experiences

Among the most important tools to support the growth and success of our epistemic community is the sharing of personal experiences of neurodiversity within semi-structured discussions. The practice of sharing personal experiences of neurodiversity emerged as a key part of our efforts for many reasons. First, this practice empowers neurodiverse individuals (students, staff, and faculty) to break down the silence and stigma related to neurodiversity, to advocate for change within higher education, and to be producers of knowledge (rather than subjects of research) about neurodiverse experiences of higher education. Since the majority of scientific research about neurodiversity frames neurological variations as a disorder or a dysfunction, the production of knowledge based on first-hand experiences allows us to challenge deficit-based narratives from an insider perspective and redefine neurodiversity as a strength. Additionally, sharing the challenges faced within higher education along with neurodiversity-related strengths invites faculty to engage with the concept of neurodiversity through empathy, builds connections among members of our community and allows community members to develop a more holistic understanding of neurodiverse experiences. The sharing of personal experiences requires both dedicated time and a safe space for authentic dialogue. This means that there is a need for an environment that provides psychological safety for sharing personal experiences that are often stigmatized and which may have been experienced as traumatic. The incorporation of strengths-based language or codes into these semi-structured discussions contributes to the creation of safe spaces in which neurodiverse individuals may share experiences, break down stigma, and build empathy and understanding between members of our epistemic community.

Discussion, Implications, and Conclusion

In this conceptual paper, we have revealed how neurodiverse learners bring needed cognitive assets and strengths to engineering problem spaces in ways that have historically not been recognized. Additionally, we have demonstrated how conceptualizing an engineering department as an epistemic community [20] can create the infrastructure for transformational departmental change supportive of neurodiverse learners. Our contestation of the deficit and pathologized individual disability framing that has historically shaped and thwarted neurodiverse learners' experiences is resisted as the engineering department/epistemic community examines the assets and diverse resources and cognitive functioning of neurodiverse learners in the context of the social ecological theoretical framework [22]. This framework shifts from an individual deviating from a norm and in need for accommodations to a population capable of benefiting from the cognitive diversity found across individuals leveraging diverse assets within a population [7]. In line with the social ecological theoretical framework, we revealed how codes like "neurodiversity" in place of "disability" served as a way of moving away from what learners could not do and instead has focused faculty attention on the unique and diverse cognitive functioning of what learners can do. Additionally, we demonstrated how the social ecological theoretical framework and codes became inscribed in tools like, communications, curricular standards, and commitments such that faculty were supported to learn from and with one another in relation to how they communicated and prepared and taught their courses.

Through this conceptual paper focused on supporting neurodiverse learners, we have contributed a vision for a more inclusive and just possible future supportive of neurodiverse learners that concurrently bestows benefits to society [7]. Further and important in the context of engineering education, we revealed how the reciprocally refining elements of epistemic communities can serve as infrastructure for transformative change in engineering departments. Our work contributes to the literature focused on neurodiversity as it extends and explores how diverse cognitive functioning can be supported in engineering education contexts, especially in higher education in engineering at the department level. Additionally, our work leverages epistemic communities as a framework for theorizing neurodiversity, codifying this theorization in language, and infusing this theory and its accompanying codes into tools that can travel as it is used more broadly in diverse geographic locales. Here, we imagine future collaborations with networks of engineering educators nationally and internationally to reimagine engineering as a collective endeavor made better by the diverse population that is more fully represented and involved in engineering pursuits. In the end, as the engineering department and its epistemic community is further refined and expands, a more diverse and plural representation of the population seems within reach. This, along with other efforts to ensure a multiplicity of representation in engineering (e.g., through efforts to support more diverse ethnic and racial participation in engineering), holds promise for a future more diverse and inclusive field of engineering capable of attending to the plural interests of diverse communities and the complex challenges they face.

References

[1] W. J. Baumol, "Education for Innovation: Entrepreneurial Breakthroughs Versus Corporate Incremental Improvements," vol. 5, *(1),* pp. 33-56, 2005.

[2] K. Kazerounian and S. Foley, "Barriers to Creativity in Engineering Education: A Study of Instructors and Students Perceptions," vol. 129, *(7),* pp. 761-768, 2007.

[3] A. E. Zaghi *et al*, "Unique potential and challenges of students with ADHD in engineering programs," in *2016 ASEE Annual Conference & Exposition,* 2016, pp. 1-15.

[4] L. D. Goegan and G. L. Harrison, "THE EFFECTS OF EXTENDED TIME ON WRITING PERFORMANCE," *Learning Disabilities (Weston, Mass.),* vol. 15, *(2),* pp. 209, 2017.

[5] N. W. Moon et al, Accommodating Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM): Findings from Research and Practice for Middle Grades through University Education. Atlanta, GA: SciTrain: Science and Math for All, 2012.

[6] T. Armstrong, "Neurodiversity: The Future of Special Education?" vol. 74, *(7),* pp. 10-16, 2017.

[7] L. Clouder *et al*, "Neurodiversity in higher education: a narrative synthesis," *High Educ,* vol. 80, *(4),* pp. 757-778, 2020. . DOI: 10.1007/s10734-020-00513-6.

[8] M. Chrysochoou, A. E. Zaghi and C. M. Syharat, "Reframing Neurodiversity in Engineering Education," 2022. . DOI: 10.3389/feduc.2022.995865.

[9] M. Chrysochoou *et al*, "Redesigning engineering education for neurodiversity: New standards for inclusive courses," in *2021 ASEE Annual Conference and Exposition,* 2021, .

[10] S. Haft and F. Hoeft, "A Meta-Analytic Review of the Consequences of Stigma and Stereotype Threat for Individuals with Specific Learning Disabilities," unpublished, private communication, (Preprint).

[11] E. M. Radulski, "Conceptualising Autistic Masking, Camouflaging, and Neurotypical Privilege: Towards a Minority Group Model of Neurodiversity," *Hum. Dev.,* vol. 66, *(2),* pp. 113-127, 2022. . DOI: 10.1159/000524122.

[12] U. Hallberg *et al*, "Hiding parts of one's self from others – a grounded theory study on teenagers diagnosed with ADHD," *Scandinavian Journal of Disability Research : SJDR,* vol. 12, *(3),* pp. 211-220, 2010. . DOI: 10.1080/15017410903478964.

[13] J. M. Higgins *et al*, "Defining autistic burnout through experts by lived experience: Grounded Delphi method investigating #AutisticBurnout," *Autism : The International Journal of Research and Practice; Autism,* vol. 25, *(8),* pp. 2356-2369, 2021. . DOI: 10.1177/13623613211019858.

[14] CAST, "Universal Design for Learning Guidelines version 2.2," 2018.

[15] D. L. Reinholz and T. C. Andrews, "Change theory and theory of change: what's the difference anyway?" *IJ STEM Ed,* vol. 7, *(1),* pp. 1-12, 2020. Available: https://link.springer.com/article/10.1186/s40594-020-0202-3. DOI: 10.1186/s40594-020-0202-3.

[16] R. Chapman, "Neurodiversity and the Social Ecology of Mental Functions," *Perspectives on Psychological Science,* vol. 16, *(6),* pp. 1360-13722, 2021.

[17] M. K. Davis Cross, "Rethinking epistemic communities twenty years later," *Review of International Studies,* vol. 39, *(1),* pp. 137-160, 2013. Available: https://dx.doi.org/10.1017/S0260210512000034. DOI: 10.1017/S0260210512000034.

[18] C. G. Jung, *The Concept of the Collective Unconscious* . Princeton, NJ: Princeton University Press, 1936.

[19] C. Cortiella and S. H. Horowitz, "The state of learning disabilities: Facts, trends and emerging issues," New York, 2014.

[20] J. L. Glazer and D. J. Peurach, "Occupational Control in Education: The Logic and Leverage of Epistemic Communities," vol. 85, *(2),* pp. 172-202, 2015.

[21] B. Renzl, "Language as a vehicle of knowing: the role of language and meaning in constructing knowledge," *Knowledge Management Research & Practice,* vol. 5, *(1),* pp. 44-53, 2007. Available: https://www.tandfonline.com/doi/abs/10.1057/palgrave.kmrp.8500126. DOI: 10.1057/palgrave.kmrp.8500126.

[22] H. M. Brown *et al*, "Changing the story: How diagnosticians can support a neurodiversity perspective from the start," *Autism : The International Journal of Research and Practice; Autism,* vol. 25, *(5),* pp. 1171-1174, 2021. . DOI: 10.1177/13623613211001012.

[23] H. A. White and P. Shah, "Scope of Semantic Activation and Innovative Thinking in College Students with ADHD," vol. 28, *(3),* pp. 275-282, 2016.

[24] H. A. White and P. Shah, "Creative style and achievement in adults with attention-deficit/hyperactivity disorder," vol. 50, *(5),* pp. 673, 2011. Available: http://www.sciencedirect.com/science/article/pii/S019188691000601X.

[25] C. L. Taylor *et al*, "Characteristics of ADHD Related to Executive Function: Differential Predictions for Creativity-Related Traits," *The Journal of Creative Behavior,* vol. 54, *(2),* pp. 350-362, 2020. . DOI: 10.1002/jocb.370.

[26] C. L. Taylor *et al*, "Divergent thinking and academic performance of students with attention deficit hyperactivity disorder characteristics in engineering," *Journal of Engineering Education (Washington, D.C.),* vol. 109, *(2),* pp. 213-229, 2020. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/jee.20310. DOI: 10.1002/jee.20310.

[27] C. von Karolyi, "Visual-Spatial Strengths in Dyslexia: Rapid Discrimination of Impossible Figures," vol. 34, *(4),* pp. 380-391, 2001.

[28] E. A. Attree, M. J. Turner and N. Cowell, "A Virtual Reality Test Identifies the Visuospatial Strengths of Adolescents with Dyslexia," vol. 12, *(2),* pp. 163-168, 2009.

[29] G. Rappolt-Schlichtmann, A. R. Boucher and M. Evans, "From Deficit Remediation to Capacity Building: Learning to Enable Rather Than Disable Students With Dyslexia," *Language, Speech & Hearing Services in Schools; Lang Speech Hear Serv Sch,* vol. 49, *(4),* pp. 864-874, 2018. . DOI: 10.1044/2018_LSHSS-DYSLC-18-0031.

[30] B. Crespi, "Pattern Unifies Autism," *Front. Psychiatry,* vol. 12, 2021. Available: https://www.frontiersin.org/articles/10.3389/fpsyt.2021.621659/full. DOI: 10.3389/fpsyt.2021.621659.

[31] L. Mottron, "Changing perceptions: The power of autism," vol. 479, *(7371),* pp. 33-35, 2011.

[32] (). *APA - DSM - Diagnostic and Statistical Manual of Mental Disorders, 5th Edition, Text Revision (DSM-5-TR)*. Available: https://www.appi.org/products/dsm.

[33] (). *What is ADHD?*. Available: https://www.psychiatry.org/patients-families/adhd/what-is-adhd#section_7.

[34] (). *Attention-Deficit Hyperactivity Disorder*. Available: https://www.nimh.nih.gov/health/topics/attention-deficit-hyperactivity-disorder-adhd.

[35] M. Nerland and K. Jensen, "Epistemic practices and object relations in professional work," *Journal of Education and Work,* vol. 25, *(1),* pp. 101-120, 2012. Available: https://www.tandfonline.com/doi/abs/10.1080/13639080.2012.644909. DOI: 10.1080/13639080.2012.644909.