

Board 161: Engineering Community Inclusion of Individuals with Autism (ECIIA): The Commitment of Community Collaborators in Engineering Education and Industry (Work in Progress)

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Abstract

The underrepresentation of neurodiverse individuals, particularly those with autism, in the field of engineering has been well-documented. The inclusion of these diverse learners must involve innovative pathways to engineering instruction. Additionally, steps must be taken to ensure inclusion and success in both educational and workplace settings through individualized supports and by effectively preparing educators, peers, and employers. Engineering Community Inclusion of Individuals with Autism (ECIIA), an NSF-funded project, will employ virtual reality (VR) technology to engage more autistic high school students in engineering. ECIIA builds off the Engineering for US All (e4usa) project, a high school program that expands student and teacher access to engineering. The project will apply the five design elements of collaborative infrastructure to engage *Community Collaborators*. Community Collaborators include stakeholders such as e4usa high school educators and students, engineering education and VR researchers, and engineers in industry. Autistic individuals serving the role of *Autism Advisor* will inform all stages of the project, and support Community Collaborators as they gain an understanding of autism and evidence-based practices, develop a collective commitment to the project, and identify individualized commitment goals and objectives that will increase inclusion and advocacy. In sum, ECIIA will lead to the development of VR that is disability-responsive and lay the groundwork for change by building a network of Community Collaborators to broaden participation and foster authentic inclusion in the field. The work in progress presents the overall project and preliminary results from focus groups and surveys collected from both Community Collaborators and Autism Advisors as they engage in the project.

Engineering Community Inclusion of Individuals with Autism (ECIIA): The Commitment of Community Collaborators in Engineering Education and Industry (Work in Progress)

In the August 2021 Dear Colleague Letter, the National Science Foundation (NSF) Directorate for Education and Human Resources (EHR) and the Division of Human Resource Development (HRD) called for increased accessibility to and diversity of science, technology, engineering, and mathematics (STEM) fields and STEM education to include marginalized and underrepresented people¹. In the NSF 2022-2026 Strategic Plan, Strategic Goal 1 aims to broaden the participation of the "Missing Millions" or under-served, underrepresented, and marginalized populations to fully participate in STEM². Furthermore, the Committee on Equal Opportunities in Science and Engineering (CEOSE) is charged by the United States Congress to advise NSF to increase the full participation of women, historically underrepresented racial and ethnic populations, and neurodiverse individuals within all levels of STEM fields³. In the CEOSE 2021-22 Biennial Report: Making Visible the Invisible – Understanding Intersectionality, CEOSE further emphasizes that work remains regarding broadening participation and diversity, equity, inclusion, and accessibility in STEM education and the workforce³.

Importance of and Barriers to Engineering Access for Autistic Individuals

Efforts to diversify the engineering field will lead to advancements in technology and innovation⁴. However, there continues to be little diversity, with autistic individuals representing one of these marginalized groups in engineering⁵. The Centers for Disease Control and Prevention (CDC) and Autism and Developmental Disabilities Monitoring (ADDM) Network report that 1 in 36 children are diagnosed with autism in the United States, with 12% of students ages 3–21 being served in schools under the Individuals with Disabilities Education Act (IDEA) in the 2021–22 school year⁶⁻⁷. As a spectrum disorder, no one autistic person is alike. This heterogeneous population varies in severity with social skills, verbal and nonverbal communication, and restrictive and repetitive behavior, and sensitivity to environmental stimuli⁸⁻⁹.

Approximately 80% of autistic individuals are unemployed, which impacts financial outcomes and quality of life¹⁰⁻¹¹. In addition to employment and stability that could be provided through a career in engineering, engaging in engineering education ensures that this population develops engineering thinking skills that will enable them to participate and make informed decisions⁴. Autistic individuals in the engineering workforce are limited because they are underrepresented at all points along the educational pathway in engineering. Kouo et al. (2021) identified limited literature on the perspectives of engineering educators and suggested strategies, including accommodations and modifications, aimed at supporting autistic students in K-12 instruction, higher education, and in employment¹². The authors recommend that continued work must be done to prepare educators, employers, and peers to better understand and support autistic individuals. Therefore, the inclusion of these diverse learners must involve novel pathways to engineering instruction and opportunities by exploring their potential and their needs¹³. Additionally, further steps must be taken to ensure success in both educational and workplace settings through individualized supports that address challenges and capitalize on the strengths of autistic individuals. Educators, peers, employers, and colleagues must effectively be prepared. Innovative and comprehensive approaches to engineering learning that engage autistic individuals and others in education and industry must be explored to meaningfully broaden participation and sustain and scale it.

Engineering Community Inclusion of Autistic Individuals

Funded by the National Science Foundation (NSF), Engineering Community Inclusion of Individuals with Autism (ECIIA) aims to broaden the participation of high school autistic students, who have historically been excluded from or under-served in both engineering education (i.e., secondary, higher education) and industry. ECIIA addresses the following research questions: (1) Is virtual reality (VR) effective in increasing access to engineering education for individuals with autism?; (2) Does participation in the VR environment and accompanying support result in the development of engineering identity, engineering self-efficacy, engineering interest, and an understanding of the engineering design process?; (3) Does supporting individuals with autism in the VR environment as Community Collaborators

result in increased understanding, and presumed competence and advocacy for individuals with autism to be included in engineering industry? What knowledge of autism is needed to be effective?; (4) Does the project lead Community Collaborators to increase collective and distributed leadership?

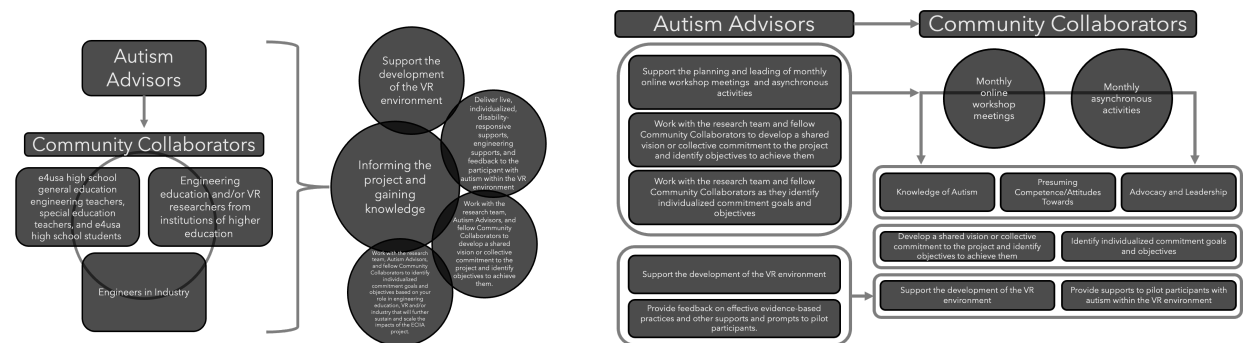
The project innovatively leverages virtual reality (VR) technologies and will connect and advance the mission and research agenda of Engineering for US All (e4usa). Three activities from the e4usa curriculum are being developed within a VR environment to provide an authentic and immersive experience that is responsive to the unique needs of each autistic participant. The activities will require engagement in the engineering design process that will support the development of engineering identity, self-efficacy, and interest. ECIIA also involves the development of an inclusive community of high school engineering teachers and students who are or have engaged in e4usa, engineering education and/or VR researchers from institutions of higher education, and engineers in industry (hereafter referred to as *Community Collaborators*). Throughout the project, Community Collaborators will be guided by the lived experiences of autistic individuals serving as Autism Advisors. In sum, ECIIA aims to help broaden the participation of autistic individuals in engineering by supporting the development of VR that is disability-responsive, informing the fields of technology, engineering, and special education, and laying the groundwork for systemic change by engaging autistic individuals as co-researchers, building a network of Community Collaborators to broaden participation and foster authentic inclusion in the field.

Autism Advisors

The neurodiversity movement subscribes to the tenet “Nothing about us without us,” and this is respected throughout the ECIIA project. ECIIA ensures that autistic individuals serving the role of Autism Advisor will inform all stages of the project, including Community Collaborators’ collective commitment to the project and individualized commitment goals and objectives that will further sustain and scale ECIIA. Five autistic individuals will be recruited to engage in both years of the project to ensure that the end user is engaged in all aspects. In Year 1 where the VR environment is being designed and developed, Autism Advisors will inform the project based on their lived experiences with autism and ensure that the project, research team, and Community Collaborators maintain *asset-mindsets*—seeing all students as having strengths and being capable of learning (i.e., presuming competence)—instead of *deficit-mindsets*—focusing on student limitations and relying on stereotypes about who can achieve. In Year 2, their input will also be critical in ensuring that the VR environment is disability-responsive in terms of sensory processing and receptive and expressive communication skills. Figure 1 provides further detail on the significant role of Autism Advisors in the ECIIA project.

Figure 1

Engagement of Autism Advisors and Community Collaborators



Community Collaborators

Inclusive practices are a critical element to ECIIA and involve the commitment of Community Collaborators. As presented in Figure 1, Community Collaborators will take on a dual role of informing all stages of the project based on their expertise and increasingly gain knowledge on how to effectively support and include autistic individuals in engineering through evidence-based practices. Through monthly workshop meetings and activities, the project will advance Community Collaborators’ knowledge

of and supports for autistic individuals through evidence-based practices and change their mindsets about the capabilities of this population, including their attitudes and advocacy skills.

Informing the Project. Community Collaborators will have valuable and diverse experiences as they relate to the e4usa curriculum, engineering education, VR, and practicing engineering in the workforce. Such knowledge and experiences will be essential in developing the VR content and identifying the potential supports that may be needed to help autistic participants be successful.

Gaining Knowledge and Developing Goals and Objectives. As a result of engaging in ECIIA, Community Collaborators are also expected to increase their understanding of how autistic individuals can participate in engineering when evidence-based and inclusive practices and supports are provided. Resources on evidence-based practices and resources that will change mindsets (e.g., presuming competence) include the National Clearinghouse on Autism Evidence and Practice, National Autism Center, and Autism Focused Intervention Resources & Modules¹⁴⁻¹⁶.

Aligning with the focus on inclusive practices, collective commitment from Community Collaborators will aid the development of cohesive partnerships. Early in Year 1 of ECIIA, Autism Advisors, Community Collaborators, and the research team will have a series of online workgroup meetings to refine their collective commitment to a common set of goals and identify objectives to achieve them. In Year 2, the conversation on collective commitment will continue to evolve. It is expected that each Community Collaborator, with guidance from Autism Advisors, will work to identify individualized commitment goals and objectives based on their role in engineering education and/or industry that will further sustain and scale the impacts of the ECIIA project. Consequently, mindsets will be changed, and commitment to broadening participation will occur through strategically developed goals and objectives that increase diversity and inclusion in these contexts, opportunities (e.g., auditing coursework, internships), and employee training on supporting autistic students and employees.

Five Design Elements of Collaborative Infrastructure

The NSF INCLUDES initiative is structured around the Five Design Elements of Collaborative Infrastructure: Shared Vision, Partnerships, Goals & Metrics, Leadership & Communication, and Expansion, Sustainability & Scale¹⁷. The first element emphasizes identifying specific challenges in STEM participation, especially for underrepresented groups, and devising innovative solutions. Partnerships are crucial and involve organizations with relevant expertise and roles ensuring that those most affected by the challenges are actively involved. Clear, measurable goals and outcomes are set, with robust data collection and use strategies to demonstrate systemic change. Leadership within projects must be distributed, with a strong emphasis on communication and conflict resolution. Finally, the initiative looks towards the future, planning for the expansion, sustainability, and scaling of successful strategies, and detailing how these efforts will contribute to a more diverse scientific workforce. This structured approach ensures a holistic and effective response to the challenges of broadening participation in STEM, and the ECIIA project addresses these Five Design Elements of Collaborative Infrastructure.

e4usa Curriculum

e4usa democratizes and demystifies engineering for all. A first-of-its-kind, national initiative, e4usa introduces engineering knowledge and design principles to a new generation of students. The curriculum developed by e4usa includes hands-on engineering projects, and it is designed to be engaging and relevant to real-world problems. Furthermore, it seeks to promote not only technical knowledge and skills but also creativity, critical thinking, collaboration, and communication skills essential in the engineering profession.

The ECIIA project connects and advances the mission and research agenda of e4usa. Three lessons from the first two units of the e4usa curriculum will be developed within a VR environment. The lessons stem from Unit 1: Engineering is Everywhere, which explores the essence of engineering and its presence in daily life, and Unit 2: Engineering is Creative, where students transition from group work to teamwork to tackle global engineering challenges. ECIIA focuses on hands-on activities and lessons related to Potable Water in the Community, Rain Shelter Design, and Hazardous Waste Cleanup Design.

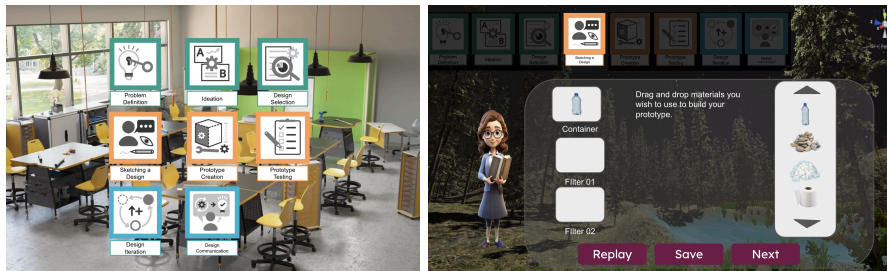
In lessons related to potable water, students are introduced to a common global problem of clean water and students engage in the engineering design process to design a solution. With the hands-on activity related to rain shelter, students learn the basics of a functioning team as they develop a rain shelter. Students then design and construct a robotic arm to lift a bottle of “highly radioactive product” and move it to a designated space.

VR Development Storyboarding

As shown in Figure 2, the ECIIA project team is storyboarding the lessons on Potable Water in the Community to support the development of the VR environment and to gather feedback from Autism Advisors and Community Collaborators. The storyboard also contains scripts and additional visual supports to guide autistic learners through the steps of the engineering design process.

Figure 2

Sample Storyboard of Potable Water in the Community



Statement on Identify-First Language

We are intentionally not using person-first language in the manuscript. This is a complex issue, however, autistic individuals have expressed a strong preference for the use of identity-first language¹⁸⁻²⁰.

Purpose

Specifically, the work in progress presents preliminary reflections on the collaboration with Autism Advisors and results from focus groups and surveys collected from Community Collaborators as they begin to engage in the project.

Methodology and Analytic Approach

Participants

Autism Advisors

The project engages 5 autistic individuals in the role of Autism Advisor. Several of the Autism Advisors have support from their family members. With a background in VR game design and education design, one of the Autism Advisors is also serving a secondary role of Community Collaborator in industry.

Community Collaborators

A total of 14 individuals are engaged as Community Collaborators. A total of three Community Collaborators are current high school teachers of e4usa. Four e4usa high school students are also engaged in the ECIIA project. As part of e4usa, these students have completed engineering design projects where an individual with a disability served as a stakeholder. Five Community Collaborators have an expertise in engineering education, with several individuals being part of the e4usa project. Lastly, two Community Collaborators from engineering industry are engaged in the project.

Data Collection

Autism Advisors

Guided by the Academic Autism Spectrum Partnership in Research and Education (AASPIRE) by Nicolaidis et al. (2019), which provides practice-based guidelines for the inclusion of autistic adults as co-researchers, intentional efforts have been undertaken to ensure that Autism Advisors are effectively included and supported in the ECIIA project²¹. An informational form has been created and delivered to both Autism Advisors and Community Collaborators. Specifically for Autism Advisors, the form gathers information on how to best foster collaborative relationships, tailor meetings, and increase engagement

and inclusion. The form elicits recommendations related to engagement on Zoom (e.g., agenda and discussion items provided in advance, closed captioning, polling, breaks, wait time, breaks, limited visuals, plain text), actions following meetings (e.g., recording, transcript, summary of notes, checklist of action items), and use of assistive technologies, including screen magnifiers, screen readers, and communication devices.

Near the end of the two-year project, Autism Advisors will be invited to participate in an interview or focus group. The questions are guided by the research of Hendricks et al. (2018) and Gignac et al. (2021) and aim to gather information on the experiences of Autism Advisors as co-researchers and their perspectives on the ECIIA project overall²²⁻²³.

Community Collaborators

Data has been collected from Community Collaborators at the beginning of the ECIIA project to gauge their knowledge about autism, and their attitudes towards autistic individuals, and to measure their advocacy for autistic individuals to be included in engineering education and industry. Research from Huws & Jones (2010) and Obeid et al. (2015) informed the development of the semi-structured focus group that measures autism knowledge and attitudes²⁴⁻²⁶. The questions posed to Community Collaborators are presented in Table 1.

Table 1

Focus Group Questions for Community Collaborators

1. What comes to your mind when you think about autism? What are autism spectrum disorders in your own words?
 2. How would you know if someone has autism?
 3. Can you tell me how you got these ideas about autism?
 4. How do you think other people get their ideas about autism?
 5. How do you think autism impacts someone's day-to-day life both positively and negatively?
-

An additional survey was created to further measure autism knowledge. The survey was developed by adapting the Autism Knowledge Survey - Revised (AKS-R)²⁶, Autism Awareness Scale/Survey (AAS)²⁷⁻²⁹, Autism Spectrum Knowledge Scale General Population (ASKSG)³⁰⁻³¹, and research from Kuzminski et al. (2019)³².

A survey focused on presuming competence and attitudes towards autistic people was created by adapting the Attitude Towards Autism Questionnaire (ATA-Q)³³ and the Societal Attitudes Towards Autism Scale (SATA)³⁴. Additionally, research from Hanel & Shah (2020), Haddock et al. (1993), Harnum et al. (2007), and Nevil & White (2011) informed the development of the survey³⁵⁻³⁸.

Advocacy skills were measured by developing a survey utilizing the research of Burke et al. (2016), Taylor et al. (2023), Taylor et al. (2017), Aarons et al. (2014), Pearson & Meadan (2021), and Koren et al. (1992), as well as the Advocacy Capacity Tool (ACT) developed by Bolder Advocacy³⁹⁻⁴⁵.

Analysis

The coding scheme developed by Obeid et al. (2015) will be applied to the first focus group question "What comes to your mind when you think about autism? What are autism spectrum disorders in your own words?"²⁵ Qualitative analysis of the focus group responses to the remaining questions and additional form responses will be supported by NVivo. The data will be analyzed using inductive coding and the constant comparative method to identify emergent themes in the focus group data and questions requiring a narrative response⁴⁶⁻⁴⁷. The measure developed to assess autism knowledge will be scored using an answer sheet, which was derived from the surveys developed by past researchers in the field. Results from the survey focused on presuming competence and attitudes towards autistic people and the advocacy skills measure are summarized in the subsequent section.

Results

The preliminary analysis of data collected from Community Collaborators at the beginning of the ECIIA project presents a number of opportunities to increase knowledge and acceptance of autistic

individuals, which will be addressed in monthly workshop meetings and activities. These opportunities include learning more about the autism diagnosis process, evidence-based practices and its implementation, and hearing directly from autistic individuals and families. From this data, the monthly workshop meetings and activities have and will continue to engage Autism Advisors and their family members to share with Community Collaborators their lived experiences and perspectives. Furthermore, there is a valuable opportunity to engage others in the autism community, including other autistic advocates, and other members advocating on behalf of autistic individuals and their families. The preliminary analysis of data collected from Community Collaborators also showcases a resounding desire to learn more about autism and take action to ensure meaningful inclusion and belonging of autistic individuals in engineering education and industry.

Discussion and Implications

Equitable access to engineering is key in addressing the United States' capacity to remain globally competitive. Autistic individuals, despite increasing prevalence, remain an underrepresented and untapped group in the engineering workforce. This population provides diverse perspectives that contribute to the field. Their access to and success in engineering necessitates increased and innovative opportunities and inclusive supports and mindsets from partner groups in all pathways, including secondary education, post-secondary education, and the engineering workforce. ECIIA aims to leverage VR technologies to deliver disability-responsive engineering opportunities and supports participants' pursuit of education pathways in technology and engineering. The results of ECIIA will also further inform the fields of technology, engineering, and special education on the use of VR in the education and preparation of autistic individuals in engineering. Furthermore, ECIIA will lay the groundwork for systemic change. ECIIA is helping to broaden the participation of autistic individuals in engineering by also building a support network of Community Collaborators to foster inclusion in the field. As a result of the project, Community Collaborators will increase their understanding of autism and evidence-based strategies. Consequently, mindsets will be changed, and commitment to broadening participation will occur through strategically developed goals and objectives that increase diversity and inclusion in these contexts, opportunities (e.g., auditing coursework, internships), and employee training on supporting autistic students and employees.

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