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BOARD # 203: Engineering Community Inclusion of Individuals with Autism (ECIIA): Leveraging Virtual Reality (VR) Technology and Community Collaborators to Broaden Participation in Engineering (Work in Progress)

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Abstract

Engineering Community Inclusion of Individuals with Autism (ECIIA), an NSF Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science Initiative (INCLUDES)-funded project, advances the mission and research of Engineering for US All (e4usa™), which aims to revolutionize high school engineering education and building students' skills to become tomorrow's engineers. ECIIA leverages virtual reality (VR) technology to develop enrichment opportunities based on two hands-on activities from the e4usa™ curriculum to engage autistic high school students in engineering. With the support of VR content being developed, the ECIIA project aims to increase access to engineering education for autistic individuals and develop their engineering identity, engineering self-efficacy, engineering interest, and an understanding of the engineering design process. Another component of ECIIA is the commitment of **Community Collaborators**, which emphasizes that everyone has a responsibility and unique ability to enact inclusive change for autistic individuals in engineering. Community Collaborators will take on the dual role of informing all stages of the project based on their expertise and increasingly gain knowledge from autistic individuals serving as **Autism Advisors** on how to effectively support and include autistic individuals in engineering through evidence-based practices. In doing so, Community Collaborators develop a collective commitment to the project, and identify and act upon individualized commitment goals and objectives that will increase inclusion and advocacy in engineering education and/or industry. 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 will present continuing efforts to engage Community Collaborators and Autism Advisors, and develop VR content that will be piloted in late-spring of 2025.

Keywords: Broaden participation, inclusion, autism, engineering education, virtual reality

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Autistic Individuals in Engineering

Efforts to broaden participation in the engineering field drive advancements in technology and innovation (Advancing Excellence in P-12 Engineering Education & The American Society for Engineering Education, 2020). Autistic individuals have the potential to be key contributors in engineering (Wei et al., 2013). The Centers for Disease Control and Prevention (CDC) and Autism and Developmental Disabilities Monitoring (ADDM) Network report that 1 in 36 children (Maenner et al., 2020). As a spectrum disorder, autism presents uniquely in each individual, with variations in social skills, verbal and nonverbal communication, restrictive and repetitive behaviors, and sensitivity to environmental stimuli. To increase the recruitment and retention of autistic individuals in the engineering workforce, further supports need to be provided at every stage of the educational journey. Kouo et al. (2021) highlighted the scarcity of research on the perspectives of engineering educators and proposed strategies (e.g., accommodations, modifications) to support autistic students in K-12 education, higher education, and employment. The authors stress the need for ongoing efforts to prepare educators, employers, and peers to better understand and support autistic individuals. As a result, this requires developing new pathways to engineering education and opportunities that address both their potential and their specific needs (Ehsan et al., 2019; Kouo et al., 2021).

Additionally, the focus of many research articles related to broadening participation for autistic students in engineering is often within an article that explores STEM more broadly (Ehsan, 2018; Nachman et al, 2024; Wei et al, 2017) or more broadly addresses students with disabilities (Bellman et al, 2018; McCall et al, 2020; Moon et al, 2012). Several recent promising dissertations have explored methods to support younger autistic students in engineering (Ehsan 2020; Singh, 2024). Ehsan (2020) explored the interaction between young autistic children and their parents while engaging in an engineering design activity and found that as the students successfully completed the activity the parents provided key supports. Extending this to a classroom, Singh (2024) similarly explored how teachers within the FIRST robotics program employed strategies aligned with Universal Design for Learning (UDL) principles, such as the use of multimodal instruction, to support autistic learners in their classroom. Ehsan and Cardella (2019) also present additional analysis of case study interactions of an autistic child with their mother, again successfully demonstrating the ability of autistic students to engage in specific aspects of the engineering design process and presenting rich discussion of the process this child used in addressing the challenges. These lines of research point to the role educators can play in creating learning experiences that support broadening participation for autistic learners in engineering activities specifically. However, ongoing efforts are needed to equip educators, employers, and peers with the knowledge and skills to support autistic individuals. Inclusion of these diverse learners requires innovative approaches to engineering instruction and opportunities, tailored to their unique strengths and needs.

Leveraging Virtual Reality Technology

The use of virtual reality (VR) to augment educational experiences for autistic individuals has been well-documented and may be a powerful tool for supporting autistic individuals in engineering education (Bauer et al., 2023; Darmasti et al., 2023; Li et al., 2023; Lorenzo et al., 2023). Indeed, both Bauer et al. (2023) and Lorenzo et al. (2023) provide specific guidelines for the use of VR in interventions for autistic children and students, each highlighting the importance of involving autistic stakeholders and teachers or other practitioners in the design of these experiences through user-centered design. Yakubova et al. (2023) also presented a review of technology-based interventions to support STEM skills for autistic students and suggested that these interventions should classify as an evidence-based practice for supporting autistic students. Additional guidelines for broadening participation in STEM learning experiences for neurodivergent individuals, including autistic students, have been presented by Kouo et

al. (2021) and Martin et al. (2023). These studies align with Bauer et al. (2023) and Lorenzo et al. (2023) in suggesting that participant voice in the design is important.

Engineering Community Inclusion of Individuals with Autism Project

Funded by the NSF Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science Initiative (INCLUDES), Engineering Community Inclusion of Individuals with Autism (ECIIA) aims to broaden the participation of high school autistic students in both engineering education (i.e., secondary, higher education) and industry. The project creatively integrates VR technologies to align with and advance the mission and research goals of Engineering for US All (e4usa™). Within a VR environment, two activities from the e4usa™ curriculum are being reimagined to create authentic, immersive experiences tailored to meet the unique needs of each autistic participant. These activities will engage participants in the engineering design process, supporting the development of engineering identity, self-efficacy, and sustained interest in the field. ECIIA also focuses on building a community composed of high school engineering teachers and students with experience in e4usa™, engineering education and VR researchers from higher education institutions, and engineers from industry—collectively referred to as *Community Collaborators*. These collaborators (see Table 2 for more information) will be informed and guided by the lived experiences of autistic individuals serving as Autism Advisors throughout the project.

Ultimately, ECIIA seeks to broaden the participation of autistic individuals in engineering by developing VR experiences that are disability-responsive, contributing insights to the fields of technology, engineering, and special education, and fostering systemic change. This change is driven by engaging autistic individuals as co-researchers, and creating a network of Community Collaborators committed to promoting authentic engagement of all individuals within the engineering field.

Engineering for US All and the Curriculum

A foundational component of the ECIIA project is e4usa™, which is revolutionizing high school engineering education and building students' skills to become tomorrow's engineers. A first-of-its-kind, national initiative, e4usa™ is increasing the number of students studying engineering by introducing engineering knowledge and engineering design principles to a new generation of students. With the support of NSF funding, the curriculum developed by e4usa™ includes authentic, hands-on engineering projects. 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 and in other careers.

The ECIIA project advances the mission and research of e4usa™ by serving all students in engineering education. Two lessons from the first two units of the e4usa™ curriculum are being developed within a VR environment. The lessons are based on Unit 1: Engineering is Everywhere, which examines the fundamental nature of engineering and its role in everyday life, and Unit 2: Engineering is Creative, where students progress from group work to collaborative teamwork to address global engineering challenges. ECIIA focuses on hands-on activities and lessons related to Hazardous Waste Cleanup Design and Rain Shelter Design. The Hazardous Waste Cleanup Design lesson engages students as they design and construct a robotic arm to lift a bottle labeled as a "highly radioactive product" and transport it to a designated location, applying their engineering skills in a practical context. The next lesson to be developed in VR is the Rain Shelter Design, where students learn foundational teamwork skills and the engineering design process as they design and build a shelter.

Collaborative Infrastructure

The ECIIA project aligns with the five design elements of collaborative infrastructure, especially with the engagement of Autism Advisors and Community Collaborators. The framework follows five key design elements: Shared Vision, Partnerships, Goals & Metrics, Leadership & Communication, and Expansion & Sustainability (INCLUDES National Network, n.d.). It focuses on identifying STEM participation challenges, especially for underrepresented groups, and developing solutions. Strong partnerships ensure those most affected are involved. Clear goals and data-driven strategies track

systemic change. Leadership is distributed, emphasizing communication and conflict resolution. The initiative also plans for long-term expansion and sustainability to build a more diverse scientific workforce.

Statement on Identity-First Language

Person-first language (e.g., individual with autism) is intentionally not being used in the manuscript and in the entire project. This is a complex issue, however, autistic individuals, including the Autism Advisors engaged in the ECIIA project, have expressed a strong preference for the use of identity-first language (e.g., autistic individual; Shakes & Cashin, 2019; Robison, 2019; Gernsbacker, 2017).

Aims and Research Questions

ECIIA involves two complementary initiatives that aims to broaden the participation of high school autistic students, who have historically been excluded from or under-served in both engineering education and industry by innovatively leveraging VR technologies. First, ECIIA involves the development of a group of Community Collaborators. Throughout the project, Community Collaborators are guided by the lived experiences of autistic individuals serving as Autism Advisors. The following research questions guide this portion of the project: (1) 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?; (2) Does the project lead Community Collaborators to increase collective and distributed leadership?

Second, ECIIA involves the development and pilot testing of VR content with autistic high school students. The following research questions guide this portion of the project: (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? Specifically, the work in progress presents continuing efforts to engage Community Collaborators, Autism Advisors, and develop VR content that will be piloted in late-spring of 2025.

Methodology

Participants

Autism Advisors

The neurodiversity movement embraces the principle “Nothing about us without us,” a value that is respected and integrated throughout the ECIIA project. Five autistic individuals serve as Autism Advisors and play a central role in shaping all stages of the project, including guiding Community Collaborators’ collective commitment and setting of individualized commitment goals and objectives that will ensure the sustainability and expansion of ECIIA. Table 1 presents background information of the five Autism Advisors engaged in the project.

Table 1

Experience of Autism Advisors engaged in the ECIIA *Project*

Autism Advisors [a]	Background
Jacob	Software Engineer with experience in educational game design and VR development.
Jordan	University student with experience in game design and with a passion for science and accessibility.
Luke	University student with autism and ADHD and interested in increasing self-advocacy skills and advocating on behalf of other autistic individuals.

Scott	High school student with an interest in majoring in electrical engineering in college.
Julianne	Behavior technician for an educational program serving autistic children.

[a] *Pseudonyms have been used for Autism Advisors*

Community Collaborators

The ECIIA project engages 14 Community Collaborators who were recruited based on their dedication to engineering education and/or engagement with e4usa™. Table 2 showcases the experiences of these individuals. As illustrated in Figure 1, these collaborators play a dual role of informing all stages of the project through their expertise while simultaneously building their understanding of how to effectively support autistic individuals in engineering by applying evidence-based strategies. Monthly workshops and activities have supported the growth of Community Collaborators' knowledge and advocacy skills, shifted their perspectives on the capabilities of autistic individuals, and strengthened their ability to provide evidence-based support.

Informing the Project. Community Collaborators bring a wealth of valuable experiences related to the e4usa™ curriculum, engineering education, VR, and the practical application of engineering in the workforce. These experiences are instrumental in shaping VR content and identifying the types of supports needed to ensure the success of autistic participants.

Gaining Knowledge and Developing Goals. Participation in the ECIIA project will enable Community Collaborators to deepen their understanding of how autistic individuals can successfully engage in engineering when provided with evidence-based practices and appropriate support systems. Resources that promote mindset shifts and evidence-based strategies include the National Clearinghouse on Autism Evidence and Practice, the National Autism Center, and Autism Focused Intervention Resources & Modules.

The collective commitment of Community Collaborators is essential for fostering strong partnerships rooted in inclusive practices. Early in Year 1 of ECIIA, Autism Advisors, Community Collaborators, and the research team participated in a series of online workgroup meetings. These meetings focused on refining shared goals, developing objectives, and solidifying their collective commitment. As this process continues into Year 2, the focus evolves each Community Collaborator identifying individualized goals guided by Autism Advisors based on their roles in engineering education and industry. These efforts aim to shift mindsets, strengthen commitment to broadening participation in engineering, and implement strategic goals that increase opportunities for participation.

Table 2

Experience of Community Collaborators engaged in the ECIIA Project

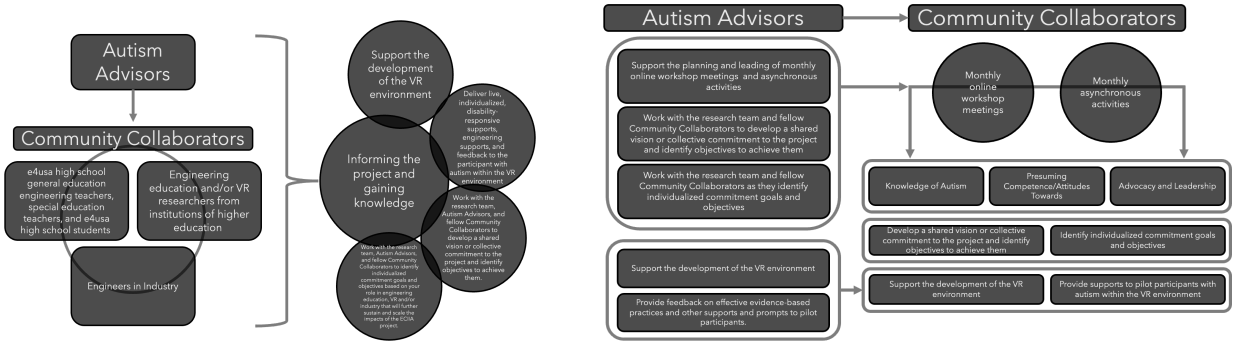
Community Collaborators [b]	Brief Background
Conor, high school teacher from Southwest	Engineering teacher at a private high school, and holds a mechanical engineering degree.
Gabe, high school teacher from mid-Atlantic	Teacher of project-based engineering classes that incorporates both STEM/STEAM and global competency and serves as a coordinator for multiple student groups.
Greg, high school teacher from mid-Atlantic	Emerging young STEM teacher who has a strong interest in broadening participation in STEM education curriculum.
Tabitha, high school	Participated in the engineering program during high school and plans on

student from mid-Atlantic	pursuing a Pre-Medicine or Mechanical Engineering degree at college.
Willow, high school student from mid-Atlantic	Completed the engineering track in high school and plans to major in Computer Engineering at college.
Adrian, high school student from mid-Atlantic	A neurodivergent student in a science and technology program and plans on studying Engineering at college.
Paul, high school student from mid-Atlantic	A brother to an autistic sibling and is interested in pursuing a degree in Mechanical Engineering at college.
Reena, higher education faculty member	Former classroom teacher, working with high school students with disabilities and currently works to connect students, teachers, schools, and other organizations with engineering design opportunities.
Terrie, STEAM education consultant	Integrated STEAM education expert with experience bringing engineering and art into formal and informal K-12 science and math programs worldwide.
Ellen, higher education faculty member	Research focuses on the lived experiences of students with disabilities in engineering education and educational policy design to support students.
Lisa, higher education faculty member	Career in STEM education focuses on increasing interest in and participation by all students and teacher professional development.
Mark, higher education faculty member	Former special education teacher and director, and school principal, and currently teaches blended university courses to address special education and STEM, focusing on supporting preservice teachers to teach engineering.
Jacon, engineering in industry	Software Engineer with experience in educational game design and VR development.
Blake, engineer in industry	Materials engineer with a Ph.D. in Materials Science and Engineering. I specialize in failure analysis, materials selection, and process development.

[b] *Pseudonyms have been used for Community Collaborators*

Figure 1

Engagement of Autism Advisors and Community Collaborators



Future Efforts: Piloting and Participants

Piloting the developed VR content with autistic high school students will be essential in exploring whether it is an effective tool for enhancing access to engineering education and if the VR content will foster the development of engineering identity, engineering self-efficacy, engineering interest, and an understanding of the engineering design process. In collaboration with a current e4usa™ high school educator teaching at a school serving students with disabilities, 4-5 autistic high school students will be recruited to participate in a two-week pilot in late-spring of 2025.

Pilot Curriculum

The first two units of the e4usa™ curriculum are being redesigned to fit the pilot's time constraints while remaining responsive to autistic individuals. Units 1 and 2 are being updated to integrate key learning objectives and provide opportunities for participants to explore engineering ethics, the design process, stakeholder roles, and teamwork. The 5E Instructional Model (Engagement, Exploration, Explanation, Elaboration, and Evaluation) is being applied to structure content delivery. Revisions are also incorporating the UDL Guidelines 3.0, along with recommendations for Individualized Education Program (IEP) accommodations and evidence-based practices to support autistic learners. Additionally, the curriculum now enriches the Hazardous Waste Cleanup and Rain Shelter Design hands-on activities by allotting ample time for VR engagement and practice with the engineering design process, with suggested educator prompts and student-facing materials, including a student engineering binder aligned with the design challenges in VR.

VR Development

The created VR environment is named Condor Brook Ecology Research Camp, where users will be greeted by several biologists and ecologists. Each design challenge will include two levels of increasing difficulty to allow autistic students to have additional opportunities to practice and generalize the engineering design process. Table 3 provides a brief description of each of the levels for the two design challenges. As an enrichment tool, the design challenges in VR will follow the classroom instruction using the redesigned pilot curriculum described in the previous section.

Table 3

Description of the Design Challenges in VR for the Two Design Challenges

Design Challenges	Levels
Hazardous Waste Clean Up Design	Level 1 Build an arm to retrieve a key that opens a food chest that has been taken by an animal across a chasm.
	Level 2 Build an arm to collect a heavy food chest that is located across the chasm.
Rain Shelter Design	Level 1 Build a hidden shelter to enable a biologist to observe wildlife.
	Level 2 Build a shelter to protect expensive research equipment.

Engagement of Community Collaborators, and especially Autism Advisors, in the brainstorming and storyboarding process, and as the VR content is being prototyped continues to be essential in ensuring that the VR content is disability-responsive in terms of sensory processing and receptive and expressive communication skills. The ECIIA project team continues to provide a number of opportunities for Community Collaborators and Autism Advisors to test and provide feedback on the VR content using Meta Quest 2 and Meta Quest 3 VR headsets. Their feedback has been imperative in informing a

multitude of iterations. Figure 2 includes screenshots of the VR environment and the Rain Shelter Design challenges.

Figure 2

Preview of Building Simulation Feature of the the Rain Shelter Design Challenges in VR

Data Collection

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

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

VR Development Pilot

Pilot Teacher and Participants

During the pilot, the pilot teacher will complete a daily reflective teacher journal and following the pilot, the teacher will engage in an interview. Data collection tools for the pilot participants will explore the effectiveness of VR as a tool for improving access to engineering education for autistic students. The pilot and data collection tools will also explore whether the VR content supports the development of engineering identity, engineering self-efficacy, engineering interest, and a deeper understanding of the engineering design process. Prior to the pilot, participants will complete a survey on their desired profession, engineering-related self-efficacy, engineering identity, and engineering interest. These questions are a subset of questions used in the research conducted with e4usa™. During the pilot, the ECIIA project team will conduct observations, engage in informal questioning, and conduct an interview or focus group with pilot participants. The observation tool will be based on the student learning objectives identified in the e4usa™ curriculum. Following the pilot, participants will complete a survey, interview or focus group, and an assessment mirroring the e4usa™ end-of-course examination.

Preliminary Results

Community Collaborators

Data collected at the beginning of the project on Community Collaborators' knowledge about autism, attitudes towards autistic individuals, and experience with advocacy provided guidance for the monthly workshops. Data indicated that Community Collaborators had an emerging understanding of autism, but needed more information about evidence-based practices. Additionally, Community Collaborators wanted to learn more about autism by working directly with Autism Advisors in the project. Community Collaborators communicated a dedication to presuming competence, but were seeking examples of how more positive attitudes may be cultivated in colleagues and peers. With regard to advocacy work, Community Collaborators were seeking strategies to improve opportunities and support systems for autistic individuals. Specifically, they were seeking recommendations to address barriers and create opportunities for autistic individuals that leverage their strengths in engineering education and industry.

As Community Collaborators engaged in the online workgroup meetings and learned more about evidence-based practices (e.g., Modeling, Prompting, Visual Supports, Reinforcement, Behavioral Momentum, Augmentative and Alternative Communication, Task Analysis, Social Skills Training, Self-Management) they also engaged in reflections on what they learned. Many shared that creating positive outcomes for autistic individuals involves fostering communities of belonging, utilizing evidence-based practices, and encouraging open dialogue. Hearing directly from Autism Advisors helped to build confidence and motivation to support autistic individuals by promoting understanding and reflecting on the impact of supportive environments. Approaches like presuming competence, using person-first language, and recognizing autistic individuals as heterogeneous and capable were also identified as important areas of growth for Community Collaborators. Community Collaborators also reflected on the impact of evidence-based practices and their universal impact in terms of supporting all individuals in all contexts.

Community Collaborators also identified goals that broaden the participation of autistic individuals within their own contexts (e.g., high school, university, industry). These goals focused on student recruitment and fostering an environment that values a spectrum of perspectives and strengths, as well as instructional practices that leverage strategies like scaffolding and differentiation to meet varied learning needs, while promoting collaboration and connections among students. Additional goals focused on practical resources, creating makerspaces to expand access to engineering programs, and integrating accessibility into design projects. Other key goals included strategies for advocating for autism acceptance, and fostering meaningful collaboration in both educational and professional settings, and ensuring all students have opportunities to succeed.

Discussion and Implications

Although the number of autistic individuals is growing, there remains a need to broaden their participation in engineering education and the engineering workforce. Autistic individuals offer unique and valuable perspectives that can enhance the field, but fully engaging their talents requires innovative opportunities, research-based supports, and collaborative efforts across all stages of education and career development—from secondary school through higher education and into engineering careers. The ECIIA project aims to break down these barriers by using VR technologies to develop opportunities designed to help autistic individuals understand and apply the engineering design process. The design of the VR content aims to be responsive to the needs of autistic individuals by engaging Autism Advisors and gathering their ideas and feedback.

Furthermore, ECIIA will lay the groundwork for systemic change by creating a network of Community Collaborators dedicated to broadening participation within engineering. This network is focusing on professional development, building knowledge about autism, and implementing evidence-based strategies to support autistic students and employees. Through this collaborative effort

with the project team and Autism Advisors, Community Collaborators are challenging existing thought patterns, setting strategic goals, and adopting proven practices to expand opportunities.

As a Design and Development Launch Pilot, the ECIIA project team hopes to expand the e4usa™ curriculum to support and broaden the participation of autistic individuals in engineering education. This will include making the pilot curriculum accessible to educators, as well as the VR content developed from this project. Furthermore, it is expected that the deliverables of this project have been universally designed to support all students seeking additional opportunities to practice and apply the engineering design process. With additional funding, scaling will occur to develop additional VR content and curriculum to support students, as well as engage an increasing number of both Autism Advisors and Community Collaborators.

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