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Work-in-Progress: Inclusive Mentoring Strategies for Neurodivergent Undergraduate Researchers in STEM

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ABSTRACT: In this work-in-progress research paper, we discuss our approaches to undergraduate mentoring strategies towards neurodivergent student's conducting undergraduate STEM research. Despite the increase in STEM students who report disabilities, few resources are available to train mentors to work with this population. The neurodivergent community is often inappropriately perceived to have disadvantages with STEM-based research and face exacerbated challenges when pursuing undergraduate research with STEM faculty.

We investigate different mentoring strategies that support neurodivergent STEM undergraduate researchers to thrive. First, we created a survey (see Appendix A) for the undergraduate research community, and we will recruit local participants to understand our research questions. The goal of the survey is to provide a first look at (1) what mentoring processes/approaches promote thriving for neurodivergent students? and (2) which strategies create a cohesive mentoring strategy to promote thriving for the entire neurodiverse community? Next, we will use the survey to identify interview candidates including professors, neurodivergent students, and neurotypical students to explore and understand various factors that empower thriving neurodivergent STEM undergraduate researchers. Increasing the success of neurodivergent STEM undergraduate students through mentorship not only broadens participation in STEM but also provides more role models for current and future students.

Introduction

In 2017, the number of STEM undergraduate students who report a disability was 19.5%. Of these students, 27.97% are enrolled in STEM fields, which leads to between 0.7-8% disabled students depending on the discipline [1]. Students with disabilities are often studied and viewed in terms of barriers they face, which provides valuable insights into the unique challenges of this population but leaves many unknowns regarding the factors that help this population thrive. For example, people in the disabled community are categorized in many deficit-based subsets, including those with chronic illness, cognitive, visual, and walking impairments [1]. Another subset of people in the disability community are neurodivergent individuals. The term neurodivergent originated in the Autism movement in 1998 and has since broadened to include individuals with dyslexia, ADHD, depression, anxiety, Tourette's, and many more neurological conditions that are typically reported as nonvisible disabilities [2].

Neurodivergent individuals are those that have brain behaviors, functions, and processing that are different from what is considered "typical" [2]. Neurotypical individuals are those that have "typical" brain behaviors, functions, and processing. Neurodiversity is a term to encompass all individuals, inclusive of both neurodivergent and neurotypical (**Figure 1**). It is important to note that neurodivergent individuals 1) are not broken or incomplete people, 2) are fully human, with inalienable human rights, and lastly 3) can live rich, meaningful lives.

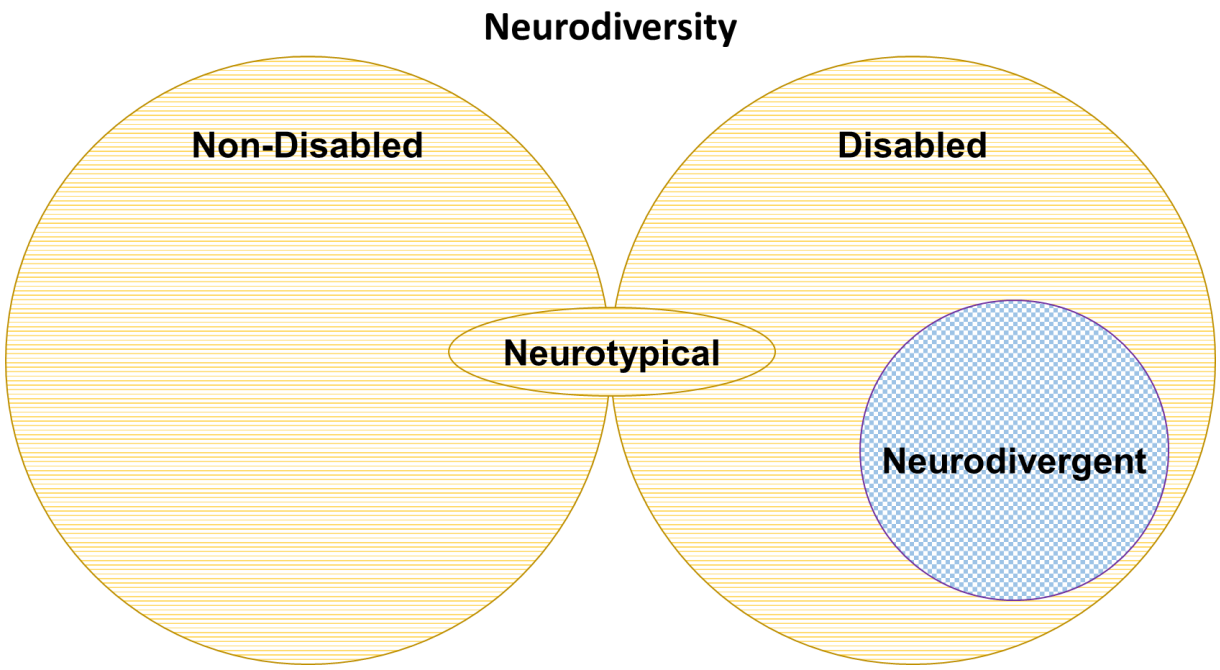

Figure 1: Neurodivergent represents a subset of people in the disability community. Neurotypical people can be those who are either non-disabled or disabled (*i.e.*, have a chronic illness but are not neurodivergent). Neurodiversity refers to the entire population of both neurotypical and neurodivergent people.

Our goal in this research project is to shift from the emphasis on deficits of the neurodivergent community by studying the contexts and mentoring practices that empower more thriving neurodivergent undergraduate researchers in STEM. The full inclusion and participation of neurodivergent individuals in society has gained traction as a matter of human rights [3], [4]. However, the full inclusion and participation of neurodivergent individuals has not translated to STEM undergraduate research and mentorship, as accommodations for neurodivergent individuals is often not implemented in research spaces due to lack of resources, the negative discourse, an outsourcing support and accommodations for neurodivergent students [4]. As diversity allies wish to become more equitable and inclusive; few resources are available to guide faculty in training and mentoring neurodiverse STEM students. One potential reason for the lack of literature around neurodivergent students in STEM undergraduate research is the inappropriate negative perception many have about neurodivergent students [5], [6]. For example, some neurodivergent students have experienced discouragement, debasement, isolation, and repeated cycles of disempowerment [5], [7]. To exacerbate the issue, many faculty are untrained to work with the neurodivergent community, and university resources tend to lean on HR or student accessibility services to develop appropriate accommodations [7]. The academic community must continue to pursue the inclusion of neurodivergent students, and this study takes the first step in understanding factors related to the individual and external environment that encourage thriving for engineering students [8].

Prior work on mentoring neurodivergent individuals shows promise for improving multiple outcomes, such as decreased anxiety, increased perceived social support from friends, academic self-efficacy, and more accurate definitions of self-advocacy [9]. Thus, we developed a survey

(in Appendix A) to explore individual and environmental factors that support more thriving neurodivergent students doing STEM undergraduate research. This survey was developed based on several factors that were previously identified to support engineering student thriving [8]. Our research questions in developing these surveys are as follows:

1) What mentoring processes/approaches promote thriving for neurodivergent students?
2) Which strategies create a cohesive mentoring strategy to promote thriving for the entire neurodiverse community?

While we are uniquely interested in the specific mentoring practices that promote thriving neurodivergent individuals in undergraduate research, we recognize that many of the questions we ask or techniques we promote could support the broader population to thrive. We hope this overall structure will support best practices to support student thriving within STEM laboratories based on neurodiverse mentorship practices.

At this time, we are working to conduct cognitive interviews with the survey. We aim to recruit participants to take this survey at the University of New Hampshire in Fall 2022. The results of the survey will help us develop and conduct interviews in Spring 2023. This paper details our work-in progress and how we developed our evaluation strategies.

Perspective on Mentoring Thriving Neurodiverse STEM Undergraduate Researchers

Just like the rest of the undergraduate STEM education population, neurodivergent students can benefit from the interactions in STEM research labs and contribute novel solutions to research problems. The success of any student is largely influenced by mentoring strategies, laboratory culture, and faculty management styles (*e.g.*, guiding, micromanaging, directing) [10], [11]. To the best of our knowledge, best practices to support more thriving STEM undergraduate students have not yet been researched.

Engineering thriving includes developing the environments, relationships, and opportunities that are most conducive to cultivating individual students' unique strengths [8]. Mentors ought to move beyond having students advocate for themselves toward creating an inclusive and accommodating environment for all students [7]. From an equity perspective, mentors ought to be trained to make sure all students are supported with appropriate accommodations, especially on neurodiversity. Applying engineering thriving towards neurodiversity might allow us to create a systematic environment towards inclusivity of the neurodiverse community.

We anticipate results will include personal, environmental, and systemic/cultural supports to support more thriving undergraduate researchers in STEM. For example, we found strategies that worked best for us but also recognized this list might not be universal. In open conversations with neurodivergent individuals, we have learned these approaches create additional support needed to support the success of neurodivergent and neurotypical individuals:

- Individual meetings where students can lead the conversation
- Informal interaction through slack or text to reduce anxiety and promote communication
- Recognizing and allowing every student to progress at their own pace

- An open dialog, or safe space, to discuss criticisms on mentoring in ***both directions*** (student-to-faculty and faculty-to-student)
- Semester strategic plan created with the student, but recognizing and allowing flexibility in week-to-week strategies
- Changing the conversation of research success from "research output" and "productivity" to "learning objectives" and "learning outcomes"
- The ultimate goal is dissemination of knowledge which can be through the publication or presentation of research. Therefore, students are encouraged to learn something and then teach others what they learned to promote dissemination of their research

Evaluation Strategy

Given the range of strategies that mentors use to promote more thriving neurodivergent students, our evaluation strategy must account for this breath of strategies and depth of experience. Thus, we plan to approach this work through quantitative surveys (Appendix A) and interviews (Appendix B) with those who have participated in STEM research. These STEM disciplines include: Biological Sciences, Chemistry, Physics, Mathematics, Earth Sciences, Natural Resources, Computer Science, Computer Engineering, Genetics, Engineering, Neuroscience, Psychology, Biochemistry, and all associated sub-disciplines. The survey will be broadly distributed to the entire University community to include neurotypical and neurodivergent individuals.

We hypothesize that more direct communication and additional mentor training are needed to optimize mentor time due to the assumption that untrained mentors often perceive that neurodivergent students need additional mentoring or communication compared to their neurotypical peers. A 2017 publication stated that neurotypical peers are less willing to interact with Autism based on thin slice judgments, which are judgments that are based on a narrow window of experience. [6]. Thus, we expect high-quality individual meetings with informal communication to promote more thriving neurodivergent undergraduate researchers. Additional training for mentors to promote individualized mentoring strategies, centered around adaptive mentoring strategies, will also support more thriving in students.

A list of our survey questions is located in Appendix A, and these questions are guided by the model of engineering thriving which summarized a thorough list of internal, external, and cultural/systemic factors relevant to thriving [8]. Furthermore, we adapted questions from the Survey for Undergraduate Research Experience (SURE) [12], the Undergraduate Research Student Self-Assessment (URSSA) [13], and the Undergraduate Research Experiences Survey (URES) [14] to create questions that target every broader category of student thriving (see Appendix C). Of particular interest are the following subset of questions around mentoring and autonomy of the mentor/mentee relationship (Q13-24), communication (Q28-36), and engagement with research (Q37-45), because we think these will highlight key aspects of thriving for neurodivergent individuals.

During the summer of 2022, we plan to conduct cognitive interviews for evidence of validity and reliability in our survey questions. Our initial study will be occurring in the Fall 2022 semester,

through this survey (Appendix A), to determine what resources best support thriving neurodivergent undergraduate researchers. Our goal is to obtain survey results from at least 25 neurodivergent and over 60 neurotypical respondents. We will examine the associations between thriving and the types of mentoring experiences for both neurodivergent and neurotypical respondents.

We will follow up on these quantitative results by conducting interviews with five labs that contain at least one neurotypical and neurodivergent student each. Our qualitative interview questions are listed in Appendix B. Our goal is to determine which strategies create a cohesive mentoring strategy to promote thriving for the entire neurodiverse community by specifically looking at mentoring strategies, laboratory culture, and Faculty management styles informed by qualitative interviews. Further, we are examining if mentors approach each student individually and are adaptable to each student's needs to promote neurodivergent students thriving.

Potential Limitations

Survey models for undergraduate research do exist, and several researchers have applied these models to assess the impact of undergraduate research in the underrepresented minority community [12], [14]. There are very few survey models, if any, that have been applied to assess if neurodivergent students thrive in undergraduate research. The neurodivergent community typically attributes itself as a non-visible difference that isn't always disclosed to the mentor. It is important to note that disclosure is up to the disabled person, and therefore, a personal choice of that individual. Disclosing a disability can led to ableist comments and further stifle the success of individuals within this community. "Ableism characterizes people as defined by their disabilities and inferior to the non-disabled," [15] and often potential allies inadvertently fall into ableist mindsets. Therefore, within this study, we also need to understand the impact disclosure has on the mentoring changes of an advisor, which could be a confounding factor in our evaluation.

Future Work

The initial results will be assessed to refine our theories and hypotheses. After the completion of this limited study, we plan on expanding the work beyond our home institution.

We acknowledge that thriving, or supporting neurodivergent students to thrive in STEM undergraduate research requires more than the core competencies detailed in our initial survey (Table C.1). We intend to confirm the interview questions (Appendix B) are sufficient to acknowledge that the thriving of neurodivergent students depends on external thriving outcomes (Table C.2) and the cultural and contextual factors in engineering for which they operate (Table C.3). Neurodivergent students may be operating in broader contextual factors that may not be structured to support their thriving. We are looking into resources and survey questions centered around systemic culture and social justice to investigate sources of systemic support for neurodivergent students.

Human Subject IRB is approved to conduct these surveys.

Positionality

Mariah Arral
I am a white woman who is an openly disabled student and comes from a disenfranchised socioeconomic background (as defined by NIH guidelines) [16]. I identify as a dyslexic and Autistic individual, and I alternate between identity-first and person-first language [17]. I was diagnosed with my disabilities ~20 years ago, and in the process of making an inclusive and accessible space for myself and others I have succeeded, failed, learned, and grown. I did my undergraduate studies in Chemical Engineering at the University of New Hampshire and conducted research with Dr. Halpern. Currently, I am a Ph.D. candidate at Carnegie Mellon University in Chemical Engineering. I have been discriminated against during my academic studies and in pursuing my research.

This research project was started in 2017 during my undergraduate studies with Dr. Halpern. I was the first openly Neurodivergent/disabled student Halpern had worked with. Throughout our relationship, we both noted there was a lack of knowledge on how best to mentor neurodivergent/disabled students in STEM-based research. We had found strategies that worked best for us, but also recognized this might not be universal. From our conversations, we sought to study STEM mentorship and thriving in a quantitative manner.

Halpern
I identify as a cis-white male who currently does not identify as a neurodivergent or disabled person. After my Ph.D., I worked briefly in industry. During that time, I had acute anxiety disorder where I clearly approached my surroundings differently. Grappling with the paranoia, a symptom of my anxiety disorder, made it difficult to have the same routine operation to STEM research and activities. My experience generated an awareness towards those who are neurodivergent and/or disabled. Furthermore, my personal experience has shown me the importance to be an active listener to all individuals, because unforeseen differences can lead to a significant impact on the way students approach research and knowledge. This mentality drove me to actively engage with Mariah in listening and learning about supporting disabled students. From this experience, I have engaged with other neurodivergent undergraduate researchers to create a framework for thriving and success. This engagement and adaptability lead to this study, and potential future studies, to try to be more inclusive with a mindset of neurodiversity.

Julianna Gesun
I am constantly reconciling my desire to support more thriving students who identify as neurodivergent with my concern that I may misrepresent or misinterpret the lived experiences of this study population. Identifying as an Asian woman with no documented disabilities or neurodivergence, I recognize my privilege in having been afforded opportunities in multiple institutions designed to perpetuate hierarchies of power and difference. For example, I was afforded the privilege and resources to complete both an engineering degree and a social science degree in college, which affects my constructivist and interpretivist worldviews on thriving within the culture, norms, and values of undergraduate engineering programs. This worldview helps me engage in reflective exercises to acknowledge and respect other realities separate from my constructions of them. Being explicit about my worldviews and the multiple truths that can

simultaneously exist has helped reconcile my desire to support more thriving engineering students who may experience lived realities incongruent with mine. With this approach toward the research collaboration, I hope to understand and empower people who may otherwise feel misunderstood and disenfranchised in the engineering education system.

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Appendix A – Survey Tool

Page1

Q1: DOB (MM/YYYY)
Q2: Major
Q3: Minor
Q4: GPA
Q5: Month and year of expected graduation
Q6: Demographics:
  a. Gender
  b. Race/ethnicity
  c. Are you pell-grant eligible? [Yes/No]
  d. Do you identify as neurodivergent [Yes/No]
Q7: Have you participated in academic research [Yes/No]
  a. Were you paid for these opportunities [Yes/No/in-part]?
  b. Did you receive credit for these opportunities [Yes/No/in-part]?
  c. Did you volunteer for these opportunities [Yes/No/in-part]?

Page2: *If NO to "Have you participated in academic research"*

Q8: Why have you not participated in Academic Research? Check all that apply:
  Too focused on studies/grades
  Unsure how to get involved
  Perceived insufficient knowledge or experience
  Rejected when applied
  Other [write in]

End Survey

Page3: *If YES to "Have you participated in academic research"*

Q9: Was your Research STEM related? Yes/No
  - If NO – End Survey
  - If YES - Continues on Page4

Page4

Q10: What department was your research professor/mentor based in
Q11: What college (e.g. COLSA or CEPS) was your research based?
Q12: How many months did you participate in research

Q13-24: On a scale from 1 (strongly disagree) to 5 (strongly agree) please rate the following statements.

1 = Strongly Disagree
2 = Disagree
3 = Neither Disagree or Agree
4 = Agree
5 = Strongly Agree

Q13: I have/had a positive relationship with me research mentor
Q14: I have/had a positive relationship with my research group members

Q15: I was in a inter-collaborative laboratory
Q16: I have transparent mentoring
Q17: I have transparent research expectations
Q18: My laboratory had high morals
Q19: I had a clear goals and direction in my mentoring experience was
Q20: The amount of time I spent doing research was meaningful
Q21: I had a lot of independence in my research
Q22: I had a lot of influence in my research
Q23: My overall research experience was positive
Q24: I received quality career and professional guidance from my mentor

Q25: Do you want to go to graduate school? [yes/maybe/no]
Q26: Did this research experience make you more likely or less likely to go to graduate school? [more likely, no change, more likely]
Q27: Has being involved with research helped keep you in STEM? [yes/no]

Q28-31: How often do you communicate with to your mentor? ---- times per month

Q28: In Person _____
Q29: Over Email _____
Q30: Over Zoom/Teams _____
Q31: Group Meeting _____

Q32-35: How often would you like to communicate with your mentor? ---- times per month

Q32: In Person _____
Q33: Over Email _____
Q34: Over Zoom/Teams _____
Q35: Group Meeting _____

Q36: The time spent with my research mentor was well used? [yes/depends/no]

Q37-45. During your research experience HOW MUCH did you:

None
A Little
Some
A Fair Amount
A Great Deal
Not Applicable

Q37: Engage in real-world science research.
Q38: Feel like a scientist or engineer.
Q39: Think creatively about the project.
Q40: Try out new ideas or procedures on your own.
Q41: Feel responsible for the project.
Q42: Work extra hours because you were excited about the research.
Q43: Work extra hours because you felt it was necessary to achieved the goals of the research.
Q44: Interact with scientists from outside your school.

Q45: Feel a part of a scientific community.

Q46: Is your research leading to a publication? [yes/ don't know/ no]

- If no to "Do you identify as neurodivergent"
  Goes to Recruitment Survey (Page6)

- If yes "Do you have identify as neurodivergent"
  Goes to Page5

Page5

Q47: During your undergraduate career, do you believe you have been discriminated against because you are neurodivergent? [yes/no]
Q48: Did/does your research adviser know you are neurodivergent? [yes/no]
Q49: While participating in research, do you believe you were treated any differently because you are neurodivergent? [yes/no]
Q50: While participating in research, do you believe you were discriminated against because you are neurodivergent? [yes/no]

- Goes to Recruitment Survey (Page5)

Page6 Recruitment Survey:
Some questions are repeated to decouple from the previous anonymous responses. Survey takers will be prompted that this is no longer anonymous with a different introduction around recruitment for interviews.

Q51: Name
Q52: Email
Q53: Major
Q54: What professor did you conduct research with
Q55: How long have you been doing research

Q56: On a scale from 1 to 5 how would you rate your research experience.
1 = Very negative
2 = Negative
3 = Neither negative nor positive
4 = Positive
5 = Very positive

Q57 Do you have a documented learning disabilities [Yes/No]
Q59a: Would you be willing to share your official documented learning disabilities?

Appendix B – Interview Questions

Interviews are scheduled for 30 min for faculty and 60 min for students. The interviews are expected to be free flowing based on the conversation. The goal is to talk about mentoring experience and whether this mentoring led to thriving in undergraduate research. These interview questions are used as prompts and guidelines to facilitate these conversations, but not every question may be asked.

Professors

I1: How would you characterize your mentoring style?
I2: What are your top 5 requirements for an undergraduate researcher?
I3: What exclusionary criteria do you use when assessing a potential undergraduate researcher?
I4: How would you describe your communication with your undergraduate students?
I5: How do you adapt your mentoring style for different students?
I6: What implicit biases do you have and how does that influence your undergraduate mentoring?

Questions for All Students

I7: What year did you get involved with research?
I8: How did you get involved with research?
I9: What motivated you?
I10: How would you characterize your mentor's mentoring style?
I11: Does this style appeal to you or would you prefer another style?
I12: What is the laboratory culture like?
I13: Did you find this supportive? Why/why not?
I14: Where you provided the knowledge to conduct your research?
I15: Where you provided the skills to conduct your research?
I16: Where you provided the direction to complete your research?
I17: Based on the knowledge, skills, and directions you were given, were you provided the opportunity of conducting your work independently?
I18: What other activities do you do outside of research?
I19: Does your research advisor encourage you to be involved with other organizations?
I20: Do you feel as though you have time to devote to things beyond research?
I21: In what ways has research impacted your future career plans and your involvement in STEM?
I22: Have you had an perceived discrimination in your undergraduate research experience?
I23: Is there anything about your mentoring experience that has been beneficial that has not been previously mentioned?

Additional Questions for Neurodivergent Students

I24: What neurodivergent diagnosis do you identify as having?
I25: Do you think that having neurodivergent status has affected how you conduct research?
I26: Does your research advisor know you identify as neurodivergent? Why or why not?
I27: During your undergraduate career, did you have a perceived discrimination based on your neurodivergence?

Appendix C- Survey questions' connections to Engineering Thriving Model

Table C.1: Questions addressing internal thriving competencies [8].

Category & Definition	Competencies Reported by Experts	Corresponding Questions from Appendices A&B.
Behavioral	Time management	Q36, I18
	Goal setting	Q17, Q19, Q46
	Responsibility	Q18, Q43
Cognitive	Tinkering	Q22, Q39, Q40
	Knowledge – Technical and non-technical	I14-I16
	global/environmental/system context/systems thinking	Q37, Q38
	Learning/self-learning/lifelong learning	Q40, I16
Interpersonal	Positivity/Gratitude	Q13, Q23
	Meaning/Purpose/Holistic Intelligence	Q41, Q42
	Curiosity	Q39
	Growth Mindset	Q21, Q22, Q39, I17
	Sense of Empowerment	Q21
	Motivation	I9, I16
	Integrity	Q18
Social	Team-work	Q14, Q15
	Professional skills	Q24
	Inclusivity	Q38, Q45, Q49-Q52, I22, I25-27
	Communication/learning skills	Q16, Q36, Q45

Table C.2: Survey questions addressing external thriving outcomes [8].

External Outcome & Definition	External Outcomes Reported by Experts	Corresponding Questions from Appendices A&B.
Health and Well Being	School/Life balance	I18, I19, I20
	Mental health	I18, I19, I20
	Financial health	Q7a
Character & Persistence	Wisdom	I14, I15
	Leadership	I16, I17
Academic & Professional	Professional conduct	I2, I3
	Retention in STEM program	Q27, I21
	Job/viable career plan	Q25-26
	Vocational fit	I2, I3, I21

Table C.3: Survey questions addressing engineering culture, systemic factors, resources, context, & situation [8].

Factor & Definition	Factors Reported by Experts	Corresponding Questions from Appendices A&B.
Personal Context & Situation	Work/Job commitments, paid or unpaid	Q7a
	Societal influences	I3
	Personal implicit biases	I3
Engineering Student Entry Characteristics	Gender	Q6a
	Race/ethnicity	Q6b
	Disability-health status	Q6c, I24
	Socioeconomic background	Q6c
University Resources	Professional opportunities	I8
	Academic advising	I1-I2, I4, I5 I10-I11, I23
	Appropriate campus resources (office hours, tutoring, counseling, etc.) to answer questions students have	I8
	Informal learning opportunities	I8
	Availability of extracurricular opportunities	I18-I19
	Research	I8
	Learning communities (cohort, classmates, etc.)	I12
Cultural and Systemic Factors	Systemic conditions of justice: procedural (equitable processes) and distributive (fair allocations of burdens, privilege, rights, and responsibilities)	I12, I13
	Diversity in knowledge-constitutive interests (different forms of knowledge and knowing)	I12, I13
	Inclusive and diverse environment	I12, I13
	Grade Point Average Requirements/Prerequisites	Q4
	Implicit biases inherent in the engineering system/Stereotypes	I12, I13
	Any systemic or structural influences that differentially affect students	I6