Identifying Faculty Learning Needs for Autism Inclusion in STEM Research Labs

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Abstract

For undergraduate students interested in STEM fields, participating in a research lab with a faculty mentor is an important developmental step for their future careers. However, autistic college students often feel devalued in academic contexts in general and experience interactions with faculty members who know little about autism or how to be inclusive to their needs. Informed by the double empathy theoretical approach to studying autism, our aim is to elucidate the areas of knowledge, skills, behaviors, and attitudes where STEM faculty most need to improve to facilitate mutual understanding within STEM research labs. We conducted focus groups and interviews with 16 autistic students (graduate and undergraduate) who had experience in a STEM research lab or were interested in STEM and 14 STEM faculty and lab staff. We analyzed the qualitative data using a training needs assessment approach, in which we focused on key gaps between what autistic students reported wanting faculty to know/do and what STEM faculty reported knowing/doing currently. We identified three overarching themes that each contained several key targets for learning: Awareness of autistic experiences (e.g., understanding the non-linear spectrum of autism and the diversity of autistic individuals), Readiness to implement accommodations (e.g., normalizing the accommodations process in the lab), and Commitment to an inclusive lab culture (e.g., providing clear norms and expectations). The three "ARC" themes can help prioritize training content for labs, as well as lab policies and procedures, to ensure that non-autistic individuals are putting forth appropriate efforts toward ensuring mutual understanding through having basic knowledge of autism, normalized accommodations processes, and specific affirming lab practices.

Background

Autistic students complete college degrees at almost half the rate of the general population (38.8%, Newman et al., 2011) and unemployment/underemployment rates have been reported as high as 85% (Shattuck et al., 2012). Structural, institutional, and interpersonal barriers hinder the participation of autistic students in the STEM workforce and in particular in undergraduate research settings. Although federal regulations mandate that higher education institutions provide equal access and reasonable accommodations to facilitate student success (Hong, 2015), studies show that inadequate accommodations, decentralized campus resources, and the "impersonal nature of institutions" contribute to lower retention and completion rates for students with disabilities (Daehn & Croxson, 2021; Marshak et al., 2010; Parks & Schule, 2009; Wessel et al., 2009), including autistic students (Wei et al., 2013).

In this study we focus on autism inclusion within an environment that serves as an important first step for many students in STEM careers—the research lab. For students from under-represented groups, undergraduate research experiences can lead to significant gains in skills and self-confidence (Hernandez et al., 2013; Lopatto, 2007) and increase intentions to go to graduate school in STEM (Carpi et al., 2017). Having a relationship with a faculty member (e.g., research mentor) is linked to academic success in STEM (Batty & Reilly, 2022; Christe, 2013; Mastronardi et al., 2021; Wineinger et al., 2022).

Although the lab environment holds promise for autistic students interested in STEM, this context also has unique barriers. Specifically, universities typically lack administrative guidelines or resources regarding student treatment in lab-based research settings (Burt, 2019; Burt et al., 2023; Posselt et al., 2020; Velasco et al., 2016). Mentoring is a largely "unscripted" activity with little institutional oversight or accountability (Posselt et al., 2020). Faculty members receive little or no training in how to be good mentors in general (Griffin et al., 2010; Karalis et al., 2022; Kimball et al., 2016; White-Lewis et al., 2022) or for autistic students in particular (Gobbo et al., 2018; Sarrett, 2018). Despite the increasing visibility of autistic individuals in society, autistic students report experiencing stigmatizing behavior from faculty members, including stereotype-based course content and dismissive behavior (Gelbar et al., 2015). Faculty members sometimes resist or refuse to provide accommodations, even when prompted by campus disability services (Kim & Crowley, 2021; Sarrett, 2018). Even when faculty members express the desire to be more inclusive to autistic students, limited experience, skills, knowledge and institutional support undermine faculty efforts (Love et al., 2015; Shmulsky et al., 2019; Sarrett, 2018). Overall, these barriers interact to maintain the status quo: research environments that filter autistic students away from STEM career pathways.

A Double Empathy Approach

Widely used theories about autism focus largely on perceived deficits (Baron-Cohen et al., 1985; Frith et al., 1991) and intervention studies tend to focus on training autistic individuals to fit into neurotypical environments (e.g., Gunn et al., 2017; Koegel et al., 2016). However, scholarship on the "double empathy problem" theorizes that fundamental differences between autistic and non-autistic individuals cause bi-directional misunderstandings (Milton, 2012, Finke & Dunn, 2025): that is, non-autistic people are also responsible for challenges that arise in interactions with autistic people. Autistic individuals are already pressured to meet neurotypical social standards (Chapman et al., 2022; Pearson & Rose, 2021), yet there is little pressure or motivation for the neurotypical majority to understand and accommodate autistic ways of being (Ai et al., 2022). Indeed, non-autistic individuals demonstrate impairments in recognizing facial expressions of autistic individuals (Sheppard et al., 2016), which affects liking of autistic individuals (Alkhaldi et al., 2019). The socialized power difference between autistic and non-autistic parties underlying the double empathy problem leads us to focus on gaps in non-autistic understanding of autistic individuals. In a research lab, autistic students typically interact with faculty members, informally and in smaller group settings than most college classrooms. Thus, power differentials exist both in terms of faculty status and neurotype/ability status. To facilitate the success of autistic college students in STEM research labs, we must understand how those with institutional power (i.e., neurotypical faculty) lack understanding of the most prominent needs of the autistic student minority.

Research Focus

Past empirical work (e.g., Shmulsky et al., 2019; Sarrett, 2018) and theoretical work (Finke & Dunn, 2025; Milton, 2012) suggest a gap between what autistic students need in order to feel included in academic spaces and what faculty and institutions provide for students. In line with the double empathy problem (Milton, 2012), there are large gaps in faculty knowledge and skills related to understanding and including autistic students. To identify specific gaps, we investigated the following research question concerning STEM labs.

RQ: What types of knowledge, skills, behaviors, and attitudes do faculty and lab personnel most need to learn in order to create and maintain an autism-inclusive STEM research lab?

We contribute to the current literature through providing guidance for future training programs. Past work on autism acceptance training has rarely focused on university faculty trainees (see Waisman et al., 2023 for an exception) and has only, to our knowledge, focused on the classroom context. Further, autism inclusion trainings for employers or undergraduate students have mostly focused on knowledge and awareness content, sometimes with input from autistic researchers or collaborators (e.g., Ashworth et al., 2025; Gillespie-Lynch et al., 2022). Our approach will specifically probe for skill and behavioral outcomes needed for autism inclusion (in addition to knowledge and awareness), and center autistic experiences through formalizing their input as subject matter experts. Moreover, by leveraging empirical data to inform the goals and content of a faculty training, we contribute directly to the growing literature on the science of diversity training (Devine & Ash, 2022).

Method

Approach

We gathered and analyzed data using a training needs assessment framework (Goldstein & Ford, 2002). Training needs assessment is a long-held standard in training (Goldstein, 1991), used for identifying targets of learning (e.g., training objectives) for a given population. Diversity/inclusion trainings have long been criticized for rarely using training needs assessment to identify training needs (Roberson et al., 2003; Thayer, 1997). Inclusion scholars have recently emphasized the benefits of having members of the underrepresented group related to the training serve as subject matter experts in the development stage, to increase the likelihood that training content will lead to greater inclusion for that group (Davis et al., 2025).

There are different types of training needs assessments, but given our research question, we took a gap analysis approach, focusing on the space between 1) what autistic students tell us faculty need to learn to be more autism-inclusive and 2) what faculty already know related to autism inclusion. This method aligns with our double empathy problem theoretical framework, in that the intended output of a training needs assessment is a list of core training (i.e., learning) needs for STEM faculty and lab staff that will enable them to close their gaps in understanding and promote inclusion of autistic students. To gather this information, we conducted focus groups or interviews (based on participant preference) from both autistic students and STEM lab leaders (faculty and staff).

Participants

Student participants. To recruit autistic students, we sent out emails and fliers with study information to autism and disability groups at a large, research-intensive public university and to contacts of the research team. We recruited 16 autistic students (graduate and undergraduate) who had experience in a STEM research lab or were interested in STEM. These students informed us of their experiences, needs, and aspects of research labs that most need to change. We interviewed 11 undergraduate students, 4 graduate students, and 1 recent graduate school alum (Mean age = 22.14, SD = 2.77). The majority (N = 13) were majoring/studying in STEM fields, with three participants reporting that they were not currently majoring/studying in STEM but were interested in doing so. Almost half (N = 7) of our participants self-identified as White, three as Asian, three as multi-racial, two as Black, and one as Hispanic.

Almost half (N = 7) of our participants self-identified as female, six as gender-fluid/gender queer/non-binary, and three as male. The majority (N = 11) of our student participants self-identified as members of the LGBTQ+ community. The majority of our participants (N = 10) reported having a formal autism diagnosis. Given autistic trait similarities between self-diagnosed individuals and those with a formal diagnosis (McDonald, 2020), we did not make formal diagnosis an inclusion criteria. Ten participants reported having lab experience, in a variety of settings (hybrid, in-person, remote) and with different types of compensation (course credit, paid, volunteer). STEM disciplines for these lab experiences were diverse (e.g., astronomy, bioengineering, entomology, psychology, statistics). For those with lab experience, four had not disclosed their autism diagnosis to anyone in their lab, three disclosed to both their supervisor and fellow lab members, two disclosed to lab members only, and one disclosed to their supervisor only.

Faculty and lab staff participants. We also recruited STEM faculty and lab staff, gaining insight into different ways that faculty construct their labs and where knowledge or skills regarding inclusion of autistic individuals might be lacking. We recruited these faculty through emails to Listservs, STEM departments, and personal contacts at our university. The 14 faculty and lab staff members in our study (Mean age = 39.71, SD = 13.77) included ten tenured or tenure-track faculty and principal investigators of STEM labs (five assistant-level, two associate, three full), three lab managers, and one research scientist. Most of this sample self-identified as White (N = 9), three as Asian, one as Hispanic, and one as multi-racial. The majority of participants self-identified as female (N = 9), three as gender-fluid/gender queer/non-binary, and two as male. One participant self-identified as autistic. The highest number of participants were affiliated with psychology (N = 5), followed by materials science and engineering (N = 2), hearing and speech (N = 2), and one person from each of the following disciplines: animal and avian sciences, biology, human development, information science, and linguistics. Though psychology was over-represented in our sample, participants' labs used diverse methods/ approaches, including: experimental set ups (N = 7), adult human participant research (N = 6), computational modeling and simulation (N = 6), child human participant research (N = 4), animal research (N = 3), fabrication (N = 3), wet lab (N = 3), and dry lab (N = 2).

Procedure

All focus groups/interviews were conducted via Zoom, lasting between 14 and 78 minutes (mean length = 34 minutes). Focus groups had between 2 and 4 participants and interviews were one-on-one. Whether participants were in a focus group or a one-on-one interview depended on scheduling constraints and/or personal preference/ accommodation. Students were in separate focus groups from faculty/staff. Autistic student participants answered nine questions focused on their experiences in higher education and/or in a lab setting (if relevant) and STEM faculty and lab staff answered nine questions focused on their lab practices and potential barriers to inclusivity (see Table 1).

Before their focus group/interview, participants filled out a pre-survey with demographics items. All participants were informed of the purpose of the study and their rights as a participant. To further increase accessibility to all, we provided the questions in advance to each participant, allowed them to use the chat function in Zoom instead of speaking out loud, and showed them how to use the closed caption function in Zoom. We also gave them the option to keep their video cameras off if they preferred to do so, told them what to expect in advance of the focus group or interview (including number of people), and explicitly discussed their ability to take breaks during the session. All participants were compensated for their time with a $50 gift card.

Questions for Autistic Students Interested in STEM	Questions for STEM Faculty and Lab Staff
1. Why did you want to join a research lab originally? What did you want to get out of it? Or, if you are not currently working in a lab - Are you interested in joining a lab, why or why not? If yes, what are you hoping to gain from the research experience?	1. What do you think is important about undergraduates being in your lab, or research labs in general?
2. Some participants have asked for modifications or accommodations in labs or in classrooms and some have not. If you did, what happened after asking for accommodations (what was the lab's response)? If you didn't, why didn't you?	2. What do you think it takes to be successful as an undergraduate in your lab (knowledge, skills, abilities, personality)?
3. Think about the way your lab is/was run, or past classrooms or work environments (format of meetings, communication norms, physical space). What works well? What does not align well with your needs?	3. What is your experience mentoring or working with autistic students? Do you have other sources of knowledge/ experience?
4. How would you define what it feels like (or would feel like) to be included or valued in a lab environment? Can you describe an example of an experience in a lab (or work or class environment) that made you feel included/valued?	4. Have you ever accommodated or modified student work duties in the past, either through formal or informal processes? In what ways? If yes, how was that experience? If no, how do you think you would approach requests for accommodation?
5. What are ways you would feel excluded or devalued in a lab setting? Can you describe an example of an experience in a lab (or work or class setting) that made you feel excluded/devalued?	5. What do you do to make your lab as inclusive as possible for students with different identities and backgrounds?
6. In your experience, in what areas could faculty or lab staff grow in terms of their knowledge about autism or neurodivergence?	6. Are there any other challenges you anticipate with including autistic students in your lab, which haven't come up yet in the discussion?
7. Some people disclose their diagnosis to some or most people in a lab or in class or at work, and some do not disclose to anyone. What was the reasoning behind your decisions? For those who disclosed, what was the response you got to your disclosure?	7. Can you describe any experiences in the past when a student was not a good "fit" for your lab? What were the issues, how was it resolved?
8. Thinking about the person who supervised your work (in lab or in an academic or work context), how would you describe their approach to supervising you? Were there any issues or points of confusion?	8. What format of instructions or meeting formats do you use with lab members? Do you adjust your approach based on the needs or preferences of specific lab members?
9. How would you prefer to keep track of tasks/ responsibilities with a supervisor?	9. How do you prefer to keep track of tasks/ responsibilities with the students you supervise? Do you use different methods depending on the student's strengths/weaknesses/preferences?

Table 1. Focus Group/Interview Questions

Analytic Procedure

Once data is collected, the next step in a training needs assessment is to develop a list of the most essential targets for training. After transcribing the focus groups, members of the research team read over each transcript and coded the qualitative data, with each transcript being coded by 2-3 members of the research team. For coding, each team developed a list of training "targets", or general areas of knowledge, skills, and attitudes mentioned by the interviewees that would contribute positively to autism inclusion in lab environments (e.g., Understand general/basic facts about autism; initiate conversations about accommodations). This process is similar to a deductive thematic analysis (Braun & Clarke, 2012) in which a specific model, theory, or framework guides the coding process and leads to a generation of themes. Specifically, a learning outcomes framework (Kraiger, Ford, & Salas, 1993) guided our team and our coding focused on ascertaining the knowledge, skills, and attitudes needed to create an inclusive environment for autistic students. Then, we discussed this list as a group and developed a shorter list that reduced redundancies, resulting in 50 training targets. To extract the most essential training targets from this list, all training targets were rated by all members of the research team on three criteria outlined by Goldstein and Ford (2002):

1. Is this objective necessary (i.e., will it come up often in a lab setting, have a big impact if done incorrectly or not done, and/or contribute greatly to autism inclusion in labs)?
2. Are faculty proficient on this objective already?
3. Can this objective be addressed feasibly through training of faculty, or is it more appropriate to address in some other way (e.g., policy change, training for students, etc)?

Results

Our coding and rating process produced approximately 20 training targets that were deemed most necessary and appropriate for faculty and lab staff to learn, and on which they were generally lacking in proficiency. From these targets we identified three overarching themes: Awareness of autistic experiences, Readiness to implement accommodations, and Commitment to an inclusive lab culture. The research team discussed each of these "ARC" themes and cross-checked them with learning objectives to validate the categories. We present these three themes, their associated training targets, and ideas for implementation in Table 2. Below, we describe each of these themes, including representative quotes. All participants are identified by a single letter if they participated in an interview (e.g., A) and by a letter and a number if they participated in a focus group with other participants (e.g., E1, E2).

Awareness of autistic experiences. This category includes training targets focused on general knowledge about autism and the experiences of autistic students. Autistic students discuss a need for faculty to increase their knowledge overall as a starting point for inclusion. For example, Participant P (an autistic student with STEM lab experience) described giving accommodations documentation to her lab PI who seemed to be caught off guard:

> "I think just general training would be great because I think especially when she was first given my ADS [Accessibility and Disability Service] stuff, I could tell it was kind of maybe one of the first times she received that. . .not from an academic class. And so it was good in the sense that she asked me what she should do with this and what would be the best way to support me with that. But I think it shouldn't all have come from me."

Participant R (an autistic student majoring in STEM) also discussed a need for "more education" for faculty, stressing the importance of incorporating autistic voices into any educational resources, so that faculty are able to "learn firsthand". This participant also discussed the barrier for autistic students when faculty are unknowledgeable about autism:

> "it's a little difficult to have faculty that might be the perfect match for you. . . [but] might just not necessarily understand how others learn in different ways."

Student participants also discussed the need to combat misconceptions about autism. For example, Participant J2 (an autistic student majoring in STEM) discussed how people often misunderstand her as an autistic person of color:

> "We're not just young white boys who like trains. It looks so different for everybody. And just understanding that there's not just one picture of autism or neurodivergence in general. I think that would be really helpful. That would be a good first step. . ."

Several student participants noted the connection between a lack of knowledge and masking, (i.e., intentionally or unintentionally hiding behaviors/traits associated with autism, Miller et al., 2021). Participant E1 (an autistic student with STEM lab experience) also discussed the need for knowledge to destigmatize autism, noting that they sometimes hide that they are autistic because they "don't want them looking down

on (them)". Participant K (an autistic student with STEM lab experience) emphasized the cost of this type of masking:

"Yeah, I can perform neurotypicality, but it comes at a cost that doesn't happen for people who are actually neurotypical."

Participant B2 (an autistic student with STEM lab experience) specifically put forth masking as an important aspect of general education about autism:

"...one thing that I would really love it if people just knew about is the idea of masking. Because I can't tell you how many times I've, you know, asked for an accommodation or talked about autism, you know, and people are just like, well, you don't need it. You're clearly fine. I, well, clearly I'm not…"

Most faculty and lab staff validated student concerns, feeling like they wish they knew more about autism. For example, Participant D (a non-autistic STEM faculty member) reported their level of knowledge of autism as "very little to none" and recounted relying on "Google searches" to understand neurodivergence in the past, due to a lack of faculty training. Similarly, Participant S (a non-autistic STEM research scientist) discussed picking up "little stray facts" throughout their life about autism, but having "limited experience" overall. Participant G2 (a non-autistic STEM lab manager) echoed a need for training, even as someone who has some personal experience with autism:

"I have not really received any training or background about how to be most supportive to students in those ways, I mean, I have people in my life who are on the spectrum, but I haven't ever been presented with resources that would help me be a better boss and mentor to students."

Overall, we see that our student participants desired for a greater general understanding from faculty and lab staff about autism, both to reduce misunderstandings and to reduce the need for (and subsequent cost of) masking. Faculty and lab staff responses largely aligned with these experiences, as they mostly recounted knowing very little about autism and/or having little to no training about considerations for supervising autistic students.

Readiness to implement accommodations. This category includes training targets focused on accommodations, from inquiring about accommodation needs to actual implementation. From the student sample, past experiences of asking for and receiving accommodations are mixed. Some discuss hesitancy or delays in asking for accommodations, due to not knowing what could be available to them or anticipated negative reactions based on their or others' experiences. For example, Participant F (an autistic student with STEM lab experience) mentioned a need for lower lighting and quieter rooms in a lab space but never asked for accommodations because she "didn't know what kind of accommodations were available". Participant J1 (an autistic student majoring in STEM) said a professor told her to take off her headphones, not realizing she wore them to "dull the noise" and not to listen to music. Participant J2 (an autistic student majoring in STEM) described a negative experience she had in the workplace:

"I do disclose for school because I have accommodations just like ADS [Accessibility and Disability Services] accommodations. And for work I did disclose, but nobody did anything. So, I don't know if that's worse or-- I'd say it's actually worse because I specifically said something and nothing happened."

Similarly, Participant B1 (an autistic student majoring in STEM) had some positive experiences in the classroom asking for accommodations, but described it as "hit or miss". They described some professors who refuse accommodation requests. Participant E2 (an autistic student majoring in STEM) stated that they would never ask for accommodations in "not just in labs", but in "any kind of academic environment" due to their friends' negative experiences in having to wait too long to receive them. In those experiences, their friends decided instead to "make their own accommodations". Participant U (an autistic recent graduate with STEM lab experience) described delaying requests for accommodations in a lab setting to be able to first "prove themselves", resulting in feeling "regularly burnt out".

Other student participants described positive experiences of having their needs accommodated, although not typically through a formal accommodations request process. Both Participant P (an autistic student with STEM lab experience) and Participant K (an autistic student with STEM lab experience) discussed not typically needing accommodations, with the former mentioning that they tended to make their "own

Training/ learning theme	Specific training/ learning target (*trainee/learner should develop...*)	Suggestions for training modality and content
Awareness of autistic experiences	Understand general/ basic facts about autism Be aware of.... • masking and the associated harm • the non-linear spectrum of autism • diversity and intersectionality within the autism community • deficit-based vs. strengths-based approach	Handout with key definitions and statistics about autistic people
Readiness to implement accommodations	Respect implementations of accommodations in the lab Be aware of accommodations for autism that might be requested Create a lab culture that is welcoming of accommodations Lead lab meetings that are universally designed to maximally accommodate difference Create a lab culture that avoids stigmatizing (or tolerating others' stigmatization of) accommodations in the lab Avoid viewing accommodations or differences within the lab as burdens Understand false conceptions about accommodations (e.g., you do not have to fundamentally change the work for an individual) Understand when and how to initiate conversations about accommodations	Brief lecture on accommodations followed by facilitated discussion of lab-specific strategies and/or role-playing exercises
Commitment to an inclusive lab culture	Be aware of lab practice ideas for helping autistic people feel included (e.g., clear expectations, respecting and seeking their opinions, flexibility in modes of communication, etc.) Be aware of lab practices that can alienate autistic people (e.g., putting people on the spot, not giving clear instructions, feeling like you need to explain autism to allistic individuals all the time, etc.) Create clear expectations with milestones (e.g., mutual expectations documents, written instructions, meeting minutes, using specific programs, etc.) Provide appropriate and actionable feedback Avoid bias in hiring for the lab (e.g., focusing too much on a feeling that someone is a "good fit" based on perceived personality) Create an open environment in the lab for expressing concerns and asking questions Be aware of how lab spaces and equipment might affect people with autism Increase explicit social norms (e.g., rules/practices that you might think students will just "pick up")	Brief lecture on lab practice "dos and don'ts" followed by facilitated discussion of ideas for concrete changes to one's lab and facilitated goal-setting with discussed plans for accountability

Table 2. Training Themes and Targets

adaptation" when needed and the latter discussing that they did not have daily accommodation needs, but were adequately accommodated once when an emergency occurred:

> "The only sort of accommodation thing that I got was in [year redacted], I was hospitalized and had to drop an entire semester. But the PI of the lab was really good about just being like, "All right, no problem. Take the semester off and come back in the fall. You'll still have a place here in the lab. Take whatever time you need." And that was really good. It made me feel better about withdrawing from a semester to know that I wasn't going to, that I'd have a place still."

Participant O (an autistic student with STEM lab experience) also discussed not needing accommodations or modifications, due to their advisors being "amazing people" who were "flexible with everything", suggesting a lab environment that explicitly or implicitly follows universal design principles.

Faculty and lab staff responses aligned with student experiences. They described little experience of accommodation requests in their lab or some experience with informal requests. For example, participant I2 (a non-autistic STEM faculty member) did not mention experience with formal accommodations request in the lab, but spoke about taking the approach that "not everybody is well-suited for everything" and seeing modifications as a way of finding a "match between the work activities. . . and the interests of the students." Participant H1 (a non-autistic STEM faculty member) similarly discussed a lack of experience with accommodations requests, but beginning to question their approach to modifications:

> "...I haven't had instances with somebody who has told me they needed accommodations [in the lab], but I've definitely had instances in which somebody failed to meet those obligations that they said they would. . . I think it's probably better for me to start thinking about, just generally, having some of those contingencies written out to the extent I could anticipate stuff like that, and making it a bit more accessible rather than just sort of come ask me when you have a problem..."

The autistic students in our sample discussed a desire to normalize needing accommodations and the accommodations process itself. For example, participant J1 (an autistic student majoring in STEM) would prefer it if needing "different things" in a work or academic setting were seen as "totally fine". This participant stated:

> "As long as you're doing the thing that needs to be done, it shouldn't be a problem. . . just don't make it a big deal. It doesn't need to be."

Participant U (an autistic recent graduate with STEM lab experience) also implied a desire for working in a place where "people's needs are anticipated and asked about" but added that the environment also needs to be a "space to feel safe saying what would help". Participant B1 (an autistic student majoring in STEM) gave an example of what this middle-ground might look like, describing a classroom setting where they felt a professor successfully normalized accommodations:

> "...one professor. . . in the beginning of the semester she sent out [a survey] and one of the questions was like 'What are your access needs' and she is like not 'whether or not you have like a documented disability, everybody has needs in the classroom', like 'how can I support you?' ... if you're asking for accommodations, it has to come from the person asking for it being like advocating for yourself versus if it's a norm of like, 'Hey, how can I support you?' Then it makes it a lot easier to be like, 'These are the things that I need to be successful.'"

Overall, accommodations in a lab context were an informal process and often not explicitly requested, with a wide range of positive and negative experiences from the student perspective and a preference for the accommodations to be a more regular, integrated part of the research (and work and classroom) context.

Commitment to creating an inclusive lab environment. This category includes learning objectives focused on changing policies, procedures, and practices to create a general environment where autistic students feel welcome and comfortable. One area was the need for explicit norms and a degree of predictability, including aspects of the lab where it might be assumed they can intuit hidden or implied meanings. For example, Student E2 (an autistic student majoring in STEM) discussed experiencing "points of confusion with every word they say" when getting directions from a supervisor. Specifically, he recalled not being able to figure out "whether or not [the supervisor was] kidding" or whether they wanted him "to get on something right away" or "wait on it". Similarly, Participant E1 (an autistic student with STEM lab experience), described feeling "lost and behind" when "communication isn't adequate" and Participant C3 (an autistic student with interest in majoring in STEM) states they do not do well with "just auditory instructions". Unrelated to task instructions, Participants J1 and J2 (autistic students majoring in STEM) discussed issues around norms at work-related social events, with J2 describing such events as "forced fun events that have weird rules that make even less sense than usual". She specifically highlighted how difficult it can be to "figure out what the boundaries are when it's an explicitly work event". Participant J1 explained that "new situations are terrible" and described having "nightmares of going to company socials and such".

On the positive side, several participants discussed examples of clear communication that increase (or would increase) their feelings of inclusion. For example, Participant A (an autistic student with STEM lab experience) discussed how being provided clear instructions was helpful:

> "I think the bullet pointed list [provided in a past lab] was really helpful to me in terms of like 'Hey, I'm doing this this week.' I'm telling you so I can be accountable. And then check in next week to see if I actually got those things. So I guess in that way, like that was really useful."

Participant R (an autistic student majoring in STEM) noted the benefits of meeting notes or outlines ahead of time to be able to "keep up with whatever topics" come up in discussion. They note how they "tend to struggle when there's less structure", adding that structure results in "less confusion. . . and some type of way to follow along." Participant C3 (referenced above as disliking having only auditory instructions) described the utility of in-person demonstrations of tasks.

> "What worked well was having the instructor do a demonstration of what you needed to do for some previous labs just having step-by-step and instructions work."

Beyond barriers related to clarity, students noted how pressure to mask their autism can be a large obstacle to full inclusion. Participant A (an autistic student with STEM lab experience) discussed struggling with masking and described presenting themselves "a little more extroverted" than their true personality "out of self-preservation". Participant E2 (an autistic student majoring in STEM) detailed the link between masking and exclusion:

> "I've never really felt included in any kind of workspace or academic space. I feel kind of like the odd one now, I've often been called like the funny guy, cause I'm like, like I have odd behaviors. . . I have to mask and I'll just go along with it and then I'll have my own time where I can actually feel included in my own space when I'm alone."

Finally, participant J2 (an autistic student majoring in STEM) discussed workplaces in general and how judgment from neurotypical individuals can lead one to mask:

> "I know what it's like to not feel valued. I think that's a bit easier for me to define. I know that a lot of workplaces and stuff like that they will say that they want diversity, but then they don't actually like diversity when you do something that's different."

Whereas masking leads several of our participants to feel devalued, encouragement to share opinions and be part of a lab or work environment leads to feelings of inclusion. For example, Participant K (an autistic student with STEM lab experience) discussed how they felt "really appreciated" during lab meetings and had a PI who really took their contributions seriously:

> "So they didn't devalue my scientific perspective due to my lack of official experience. And that felt really, really good, and it felt like I was valued as a member of the lab."

Similarly, Participant O (an autistic student with STEM lab experience) described having an advisor who encouraged them to share their ideas, which led them to share despite their "terrible imposter syndrome". Participant C4 (an autistic student with STEM lab experience) also felt his input was "always welcome" in his lab, which increased their comfortability in contributing.

In contrast to these experiences, Participant P (an autistic student with STEM lab experience) described being "constantly talked over", which was "very disheartening" because she felt she had "something valuable to bring" to her lab. In summary, autistic students described several ways to feel included in a lab: clarity of norms and expectations, a space where they do not need to mask, and valuing of their input as a member of the lab.

Discussion

Our aim is to better understand how to foster the inclusion of autistic individuals in STEM research labs through improved neurotypical understanding of autistic individuals' needs and experiences. We focused on the context of the university research lab and what faculty and lab staff could learn to increase inclusivity. Through qualitative interviews and focus groups with two groups with relevant domain experience (i.e., autistic students; STEM faculty/lab staff), we identified several key targets for learning for STEM faculty and lab staff. Our results suggest that STEM research labs could both attract more autistic students and improve their lab experiences by increasing their 1) Awareness of autistic experiences, 2) Readiness to implement accommodations, and 3) Commitment to an inclusive lab culture (i.e., "ARC").

The need for increased awareness and knowledge of autism came from both faculty/staff and autistic student participants. These findings underscore that in spite of increased awareness of autism on college campuses, misinformation and false stereotypes persist (Tipton & Blacher, 2014; Zeedyk et al, 2019). Many faculty would benefit from training that provides basic information on autism and combats misinformation. Consistent with the double empathy framework, greater knowledge about differences in communication style and sensory experiences can improve communication between autistic students and faculty.

We identified accommodations as a prominent theme from the data, which underlines their importance to achieving equity for individuals with disabilities (Singh et al., 2024), and perhaps more so in the relatively unstructured environment of a research lab. Importantly, one key facet of this theme is a desire for a normalized process of accommodations, in which faculty and lab personnel inquire about the resources students need to succeed. This aligns with an in-depth case study of a highly inclusive organization with many disabled employees (Groggins & Ryan, 2013). Groggins and Ryan found that at this organization, accommodations are the norm and an expectation, not the exception. Employees at this organization are immediately consulted to determine how any barriers in the work environment could be mitigated to meet their unique needs. The researchers note that this view on accommodations leads to an openness to changes in general and fewer strict rules on "how things should be" (p. 272). In a research lab, by making accommodations the explicit norm, our data suggests that autistic individuals will feel more inclined to advocate for what they need to successfully contribute to the research team.

The final "ARC" theme centers on commitment to an inclusive lab culture. Some of the lab practices represent functional changes that assist autistic students in understanding explicit rules and/or aid in executive functioning, but others are more related to the psychological climate (i.e., individual perceptions of the environment, Jones & James, 1979) of the lab. Specifically, students want to work in a place where they do not have to mask and feel encouraged to share their opinions and thoughts. Masking is an experience that uses considerable internal resources that often results in negative individual outcomes (Cage et al., 2022; Miller et al., 2021) and is indicative of the typical one-sided empathy gap between neurotypical and autistic individuals (Ai et al., 2022). An environment without the pressure to mask would reflect true mutual understanding and increase the likelihood that these students enact their authentic selves. Scholars have theorized that individuals in the minority or marginalized will be less authentic at work, due to environmental facets such as feeling like they do not "fit" the context, cannot take risks without fear of reprisal (i.e., low psychological safety; Kahn, 1990), and have low autonomy overall (Schmader & Sedikides, 2018; Wessel et al., 2020a). In general, feeling authentic at work relates positively to outcomes such as job and life satisfaction, well-being, and negatively to stress (Cable et al., 2013; Wessel et al., 2020b; Wood et al., 2008). By creating lab spaces where students feel encouraged to share their true-felt opinions and be their true autistic selves, faculty would promote greater autistic inclusion.

Practical Implications. The goal of creating these learning targets is to use them to create training modules that can be delivered to faculty and lab staff. Given the limited time of most academics, we recommend institutions prioritize learning outcomes from our list based on their own institution's needs. Further, targets involving basic declarative knowledge or awareness (e.g., Understand general facts about autism; Be aware of accommodations that might be requested) can be reached through more passive instruction (e.g., infographics, handouts; Bell & Kozlowski, 2001). More active and involved in-person training can be reserved for the skill targets (e.g., Create clear expectations with milestones). Although our focus was STEM labs in university settings, many of the learning targets, such as a basic knowledge of autism and normalizing accommodations, can be adapted to other university and industry settings.

Overall, more inclusive labs should lead to increased satisfaction with the lab, greater retention, and increased interest in graduate school and STEM careers. We see inclusion training as a good start. To maintain an inclusive lab for autistic students, check-ins with advisory boards or student groups that include autistic individuals would help monitor inclusivity in an ongoing way. We also recommend providing resource guides to new faculty and/or creating faculty communities of interest, as diversity training effectiveness increases when it is integrated into other areas of the institution (Bezrukova et al., 2016). Moreover, some learning targets, such as creating explicit guidelines for labs, could be institutionalized such that they are a part of the everyday expectations for faculty, regardless of access to training.

Potential Limitations. Faculty and lab staff interviewed knew the topic of interest and were likely more supportive of including autistic students than the broader population. However, we still identified many gaps in knowledge and skills, giving us no indication that this group was unusually fluent in autism inclusion. Trainee motivation is an important predictor of training success (Tziner et al., 2007), and contexts adapting the ARC framework to their own institutions may want to assess the local level of motivation and adjust content (e.g., add in more justification for training) if trainees are less motivated. Further, our sample of autistic students may differ from the broader population of autistic college students in STEM. Though we have no specific demographic statistics available for autistic college students in STEM, our sample was more racially diverse than the U.S. population of college students (Bauman & Cranney, 2020) and come from one national context. Also, a meta-analysis found that autistic adults are significantly more likely to identify as LGBTQ+, but still at rates lower than we found in our sample (Pecora et al., 2016). This could limit the generalizability of some of our learning objectives; however, we see the diversity of autistic experiences in our sample across several dimensions as contributing to our goal of identifying many different gaps in knowledge and skill.

Conclusion

Guided by the double empathy problem and utilizing a training needs assessment methodology, we identified key learning outcomes needed for faculty and lab staff to create and maintain autism-inclusive STEM research labs. We sourced these themes (and associated training targets) from relevant personal experience from autistic students interested in STEM as well as STEM faculty/lab staff. Our autistic student sample

was particularly informative for identifying what inclusion would actually mean for this community of students and where the largest gaps exist in this unique educational setting. The three "ARC" themes can help prioritize training content for labs, as well as lab policies and procedures, to ensure that basic knowledge of autism, normalized accommodations processes, and specific lab practices are centered. When autistic voices guide the learning priorities, resulting educational materials will have a better chance of improving the environment for the intended community.

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