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"I just love research": Beliefs about what makes researchers successful

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ABSTRACT: There is a longstanding belief that research should be a calling more than a job. How does this expectation shape the selection of future researchers? Specifically, undergraduate research experience is credited with increasing students' success in science and engineering majors and their likelihood to choose careers in science and engineering; thus, how researchers select student laboratory workers has implications for the future population of researchers. After all, because research communities construct knowledge collectively, researchers' identities and experiences crucially shape knowledge. This paper analyzes qualitative interviews with engineering professors and students about what they believe are the characteristics of a good researcher. Both groups describe the importance of a researcher feeling interested in and enthusiastic about research to be able to do good work. They also imply that good researchers must be assertive, such as by requesting jobs in laboratories. I suggest that these explicit and implicit expectations can create opportunities for implicit bias and unintentional exclusion and suggest strategies to mitigate these problems and promote inclusion for the next generation of researchers.

This paper explores professors' and students' beliefs about what it takes to be a good researcher. Undergraduate research experience is credited with increasing students' success in science and engineering majors and their likelihood to choose careers in science and engineering (Russell et al. 2007; National Academies 2017, 4-5); thus, how researchers select student laboratory workers has implications for the future population of researchers. Because research communities do collective epistemic work, researchers' identities and experiences shape knowledge.

In interviews, engineering professors said that they hire student lab workers who seem enthusiastic. This practice implies a belief that performed interest correlates with motivation, work ethic, and even ability. Likewise, undergraduates explained to me that their "interest" and "passion" inspire them to join labs, choose certain majors, and work hard. Professors also expect undergraduate researchers to be assertive, such as by requesting lab jobs, asking questions when they need help, managing their lab work, and, in some cases, designing projects. Rather than investigating the validity of these beliefs, this paper suggests implications of the mental model of success as dependent on enthusiastic and assertive behavior for undergraduate laboratory workers and, ultimately, for the diversity of future engineers.

Passion and Research

The idea of the scientist as motivated by curiosity and commitment is old. For example, people who studied nature in 19th-century Europe were expected to be "gentlemen naturalists", who were wealthy enough to avoid the biases of employment and bribery (Desmond and Moore 1991; Secord 1994). This autonomy made them credible interpreters of nature. Gentlemen of science, such as Charles Darwin, were also amateurs, in the sense that they pursued research as leisure. Their labor was rewarded by personal enjoyment, plus scientific recognition for a rare few. This love of nature was the only respectable motivation for a researcher at the time, as opposed to profit or fame. It's possible this belief has continued into today's research, though we no longer use wealth as an indicator of scientific credibility.

An influential 20th-century example of this belief is Max Weber's (1946) reflections on "Science as a Vocation", published in 1919. Weber claimed that being a scientist requires passion, inspiration, and hard work:

> Without this strange intoxication, ridiculed by every outsider; without this passion … you have no calling for science and you should do something else. For nothing is worthy of man as man unless he can pursue it with passionate devotion. (1946, 135)

This "passionate devotion" is presented as characteristic of a scientific "calling" and therefore as a prerequisite for scientists. It does not necessarily refer to happiness, but rather a willingness to work hard to pursue a scientific career: "Both, enthusiasm and work, and above all both of them jointly, can entice the idea" (Weber 1946, 136). For Weber, a researcher needs enthusiasm alongside hard work to achieve a novel and important scientific idea. Employers can use the belief that workers should love their work to justify unpaid internships, employee surveillance, and dangerous overwork (Tokumitsu 2015). This expectation also implies Marxist false consciousness, in that workers' passion can obscure their awareness of their exploitation. Employers in care occupations assume that caregivers' "intrinsic reward" and "love" for their work motivate them strongly enough to accept low pay (England and Folbre 1999; Folbre et al. 2012). Expecting workers to be passionate also demands unpaid emotional labor (Hochschild 1983), which may conflict with the expectation that scientists approach their work with objective, emotionally-detached rationality (Gieryn 1983; Daston and Galison 2007).

Yet in the 21st century, psychologists and education scholars further perpetuate the idea of enthusiasm and interest as linked to motivation and inspiration. For example, undergraduates' "passion" for a subject correlates positively with their motivation and effort in that subject's courses (Stoeber et al. 2011) and undergraduates feel happier while doing something that they are passionate about (Mageau and Vallerand 2007). I, and I imagine many other professors, hear a common refrain from students that they are working hard because they're interested in a topic (or the unfortunate opposite). However, we all pursue skills and knowledge that do not interest us, for reasons of necessity and external pressures, and we can achieve them without enthusiasm. For example, I lack interest in and enthusiasm about tax laws, but I have learned enough about them to successfully file taxes. From another perspective, we may even be good at things that don't interest us, such as the notion of "beginner's luck" when a novice with no investment in learning a game then wins. Granted, these situations involve achieving *sufficient* ability, not necessarily *excellent* ability. Nonetheless, we continue to assume that good researchers must be passionate, and visibly so.

The old idea of scientists as driven by passion is still shaping the experience of today's engineering students.[i] They learn these expectations through socialization into professional communities, such as by working in research labs where they interact with principal investigators (PIs) and graduate students. By embedding in a "community of practice", such as a lab group, novices acquire technical skills and adapt to behavioral norms through "situated learning", i.e., by practice and immersion with community members (Lave and Wenger 1991). To study how PIs' expectations and communities' socialization shape undergraduate lab workers as future engineers, I observed and interviewed research groups.

Methodology

This study draws from an ethnography of two engineering laboratory communities at a medium-sized public American university in 2016-2017 (Wylie and Gorman 2018). The labs' PIs are tenured professors with industry experience. One, Kate, studies the properties of materials. The other, Dan, develops electronic systems.[ii] Kate's lab had one postdoc, 9 graduate students, and 3 undergraduates. 8 lab members are women and 5 are men. Two lab members are minorities (i.e., from racial or ethnic groups underrepresented in science and engineering, i.e., not white or Asian). Dan's lab had one postdoc, 11 graduate students, and 2 undergraduates. 2 lab members are women and 12 are men. One lab member is a minority. Kate and Dan are white. The undergraduates had each worked in their labs for at least one term before this study, and a few had worked there for as long as three years. I chose these labs because undergraduates work in them, they represent different fields of engineering, and they have different levels of gender diversity. Crucially, the labs' PIs were welcoming to this study, in the hope that external observations and assessments would provide valuable feedback and help them improve their mentoring and their students' experiences.

This paper analyzes qualitative interviews of the labs' PIs and undergraduates, which were audio-recorded and transcribed. Through coding based on grounded theory and inductive analysis (Creswell 2007), how interviewees talked directly about enthusiasm and indirectly about assertiveness emerged as the primary selection criteria for future engineers.

These qualitative methods fill a gap in research about undergraduate students who work in labs. Most studies use quantitative surveys to measure students' and faculty's experiences and correlations with students' careers (e.g., Lopatto 2004; Russell et al. 2007). In comparison, interviews collect narrative versions of individuals' experiences, which include more subtle and varied themes than surveys (e.g., Dolan and Johnson 2010; Hunter et al. 2006).

Valued Abilities for Novice Researchers

Enthusiasm

PIs and graduate students articulate the qualities they value in undergraduate lab workers most clearly with regards to selecting new workers. They emphasize enthusiasm, which they believe to be an indicator of commitment, work ethic, and ability to learn. For example, when choosing undergraduates PI Kate values "the same things I look for in grad students, I guess, [which] are curiosity, perseverance, reasonable amount of academic success." She evaluates these traits based on how applicants respond to a lab tour: "Usually [undergrads] approach me, say, 'I'm looking for some research to do,' and I show them around the lab, and if they seem excited about it then I'm more willing to take them on." Excitement is not sufficient for selection, because Kate also expects curiosity and acceptable grades, but it is a significant factor. Also, Kate does not hire undergraduates solely for their benefit: "It's fun seeing [undergrads] so excited about stuff and so that excites me too." She appreciates that "excited" lab workers are contagious and can perhaps improve her own motivation. Kate's grad student Sam echoed Kate's approach in hiring undergrads: "I like someone that's excited and passionate about learning new things and wanting to be in a lab, because if you have that, the rest I think will do itself." By "the rest", Sam means learning how to do lab work. Sam selected undergraduate Gretchen to be his research assistant because she demonstrated a general interest in learning during her interview, though she had no prior lab experience. As a result, Sam had to teach Gretchen a lot of information and skills, but he thought she learned quickly and eventually did good work for his research. Interpreting passion as a proxy for potential lab skill proved effective for Sam in this case.

PI Dan also looks for enthusiasm in prospective workers. His decisions are “about their enthusiasm, the energy that they bring, and their ability to be thinking a little bit broader.” Dan sometimes invites students to join his lab based on their enactment of “energy”: “When I used to teach lower-level undergraduate courses, I would sometimes mention to a student who I thought was particularly energetic and bright and eager, to say, ‘Hey, I’m doing this [research], might you be interested in learning more?’” PIs assess excitement, energy, and eagerness through interactions, such as class or interviews, and not through resumes or grades. Kate and Dan both think grades are an insufficient indicator of undergrads’ potential research skill. They believe students’ demonstrated willingness to learn is more important, though they also want students who are “bright” and achieve some “academic success”.

The undergraduates agree with their PIs’ assumption that enthusiasm and excitement correlate with desire to learn and work ethic. This makes sense, because they were selected for these traits. The students talk about their choice of labs and majors in the language of preference and emotion. When I asked undergraduate Frank to explain the success of research he had recently presented at a national conference, he claimed interest as his motivation: “When I learned more about this material I was really interested in it, because it can convert waste heat into electricity … I thought it was really cool, so I worked really hard on it.” Frank credits his “interest” in a material’s applications for inspiring his willingness to invest “really hard” effort in the study, which then yielded important results.

Like Frank, other students mention enthusiasm as an important motivation for their lab work and decisions about majors and careers. For example, Gretchen’s interest in jet engines manifests in eager explanations to others: “I've taught all my friends something about a jet engine at least once.” This interest also inspired Gretchen to major in mechanical engineering and work in a lab studying materials for engines. Other lab members praised Gretchen to me for her enthusiasm, such as her enjoyment of learning new techniques and her frequent statements of “I love anything to do with science” and “science is awesome”. Gretchen talks quickly and with emphasis, such as when she told me, “I really, really, really like patterns and like identifying them, so when you get to compile all your data and identify a pattern, that's really cool.” Gretchen’s speech style could be seen as immature; instead, her coworkers interpret it as a sign of her passion for research. Like Gretchen, undergraduate Jessie explains her enthusiasm as enjoying the process of research: “I just love research. Even if the literal work that I’m doing … is boring and tedious, I like the bigger picture and like the reason why it’s happening.” Jessie’s “love” of searching for answers overcomes the tedium of everyday tasks.

The absence of enthusiasm for a topic is just as significant to students as its presence. Jessie changed her major based on her lack of enthusiasm for chemistry: “Orgo [organic chemistry] just did not sit right with me. I just wasn’t that passionate about it, and I wasn’t that into it, so I just couldn’t keep going with it. But then I liked materials a lot better [laughs].” Jessie was grateful that materials science, the major she selected despite having little experience in it, turned out to be something she “liked”. This connection between excitement, interest, and desire to learn was common in undergrads’ responses. Will, an undergraduate in Dan’s lab, also explained his favorite and least-favorite topics in terms of excitement and interest: “I’m not super interested in signal processing … I like hardware stuff a lot more … I’m not a huge statistics person, so [signal processing] is just not super exciting to me.” As a result, he avoids signal-processing research projects. The undergraduates therefore agree with their PIs that it’s important that they be excited, because it makes them willing to work hard. In addition, undergraduates use enthusiasm as a guide for their academic decisions. This latter trend suggests that undergraduates are using “excitement” to indicate that they consider something to be enjoyable and fun, without mention of whether they are good at it.

While PIs value enthusiasm as an indicator of work ethic and learning potential, undergraduates describe their enthusiasm as motivated by “fun” and enjoyment. PIs don’t say that they want students to have fun in the lab, perhaps because that sounds unprofessional or not work-devoted enough as in Weber’s (1946) portrayal of researchers. But, according to undergrads, enjoying one’s lab work can be a strong motivator for work ethic. Gretchen thrives on the freedom of research: “The responsibility is fun, like being trusted to work in a lab and figure things out.” Frank wants this fun to continue: “I definitely want to go to graduate school and be involved with research because I just think it’s a lot of fun.” Jessie so enjoys her lab tasks that, like all of the undergraduates I interviewed, she happily spends her weekends doing them: “My friends make fun of me because I’ll be like, ‘Ugh I have an SEM session on Saturday, it’s so annoying I have to go to work,’ and they’re like, ‘Are you kidding me? You scheduled that session yourself! [laughs] You want to be there.’” Similarly, Will likens lab work to a hobby: “[Research] is almost like my personal side project, but there’s a bit more structure and I have responsibilities to other people.” Working in a lab, then, provides undergraduates with opportunities for fun. They also acknowledge that lab work is sometimes *not* fun. As Jessie put it, “I do a lot of imaging on the electron microscope and stuff that might not necessarily be something that I’m like, ‘Ooh I want to do this so badly,’ but it’s really great experience.” Like the “boring” tasks she mentioned previously, Jessie portrays less-enjoyable tasks as an investment in future fun, as “experience” to lead to more research opportunities.

Undergraduates often compare excitement in lab work with boredom in class. For Jessie, “if there’s something in lab that I want to do, I will be like, ‘Screw homework! I have to do this test’ [laughs] … because I’m interested in it. And so it’s tough that I have to tell myself, ‘No, you have more boring homework that you really have to do.’” “Boring” homework is assigned to Jessie, while she “want[s]” to do lab work, which interests her and over which she has some control. Similarly, Will sees lab work as an escape from schoolwork: “Schoolwork for me is very not engaging, so research gets me going and then being able to work on things that I’m interested in.” These students’ view somewhat matches Weber’s (1946, 137) claim that scientists must focus on their field, which “holds not only for the field of science; we know of no great artist who has ever done anything but serve his work and only his work.” Schoolwork drives Will into the lab, where he can be “engaged” through hands-on, self-directed tasks. However, Jessie feels she has to sacrifice lab work, as her avocation, for schoolwork, as her vocation. Students must therefore sometimes prioritize coursework over lab work on their journey to becoming a scientist. Unfortunately, Downey and Lucena (2003, 170) found that undergraduate engineers must “cope with a loss of romance” to be good students. Their dreams of serving others through technology require autonomy, but students “must yield autonomy to the authority of the engineering method” to succeed (Downey and Lucena 2003, 170). This lack of power to pursue their interests and large-scale goals may be the source of the frustration my interviewees describe about their courses. Lab work, in undergraduates’ view, can allow opportunities for students to choose their projects and make “big-picture” contributions.

PIs and students define enthusiasm as prerequisites for doing successful research; however, they also believe passion for research can develop with experience. Kate even includes undergraduates in her lab “to help get them excited about doing research”. By hoping that lab work will inspire this interest for students, Kate implies that excitement and research experience are more of a feedback loop than a unidirectional relationship. Dan experienced this situation himself. He didn't do research as an undergraduate and went to graduate school with little knowledge of research, "but then as I started to have research experience, I really became passionate about it." As a result, it's important to him to include undergraduates in his lab to give them the research experience he didn't have until graduate school. It's interesting, then, that both PIs believe enthusiasm for research can be sparked by doing research, yet they use enthusiasm as a marker of a good potential lab worker. Some undergraduates arrive at the lab with enthusiasm, as Will and Rick did, while others develop greater enthusiasm for fields and lab work over time. For example, Jessie found that "I wanted to know more about [materials science] once I actually had my own project and my own samples and it was like – I cared more." All the undergraduates I studied are enthusiastic about research in general, such as Gretchen's love of jet engines. It seems to be this latter group whom PIs are truly looking for as new lab workers: students who are open-minded and who enjoy learning writ large. The "passion" for a specific field can come later, through working with equipment and people in the lab.

Kate challenged her own assumption about the relationship between enthusiasm and good lab skills in a story about a former undergraduate worker who lacked enthusiasm:

> She got this really cool result and she didn't even tell me … The grad student she was working with, he showed me … I emailed her, "That's so cool," and she said, "Oh, I didn't know it was of any interest!" It's like [laughs], hello! It was this crazy result. She was just Eeyore, nothing excited her.

Kate told this story with exasperation, rather than celebrating the student's "really cool" findings. Clearly, the student achieved good research work despite being Eeyore (the sad, pessimistic friend of Winnie the Pooh). This student demonstrates that enthusiasm is not always a cause or correlate of research ability. Kate told this story retroactively and I did not meet this student, but, to speculate, the student may not have been as emotionally expressive as Kate expects students to be, by personality or for cultural reasons. It's also possible, as the student claimed, that she didn't know the results were important and therefore didn't express excitement. Or perhaps the student was simply not assertive enough to email her PI, rather than unenthusiastic about her work.

Regardless of the reason, as a result of this exchange Kate disagreed with the student's career choices. Kate explained,

> She wanted to go to grad school. I was like, "Are you sure you want to go to grad school? Because you just don't seem that interested in research." She did end up going to grad school. So hopefully she found something she liked to do better.

The PI's expectation of how a future researcher should behave resulted in her lack of support for an undergraduate who didn't match that expectation. This seems unfair, especially because this undergraduate did good lab work and was accepted into graduate schools. A PI's belief that researchers should be enthusiastic resulted in the underestimation of an undergraduate's potential. In addition, this student, as a woman, belongs to an underrepresented group in engineering.

Assertiveness

Another characteristic that PIs consider crucial for undergraduate lab workers, though they don't name it explicitly, is assertiveness. They expect undergraduates to be strikingly self-aware and capable of self-direction. For example, to join Dan's group, undergraduates must contact him and ask. In Dan's words, "If somebody's interested I open the door to them. I feel like that opportunity's there, so I don't feel like I'm ever explicitly picking people as much as they kind of pick themselves." Despite Dan's open-door policy, no one tells undergrads to ask professors for research opportunities. I surmise that the cultural capital required to think of asking for a position and knowing how to ask in a professional way belongs primarily to middle-class students. Even if students are told to contact professors for lab jobs, they may hesitate due to shyness, intimidation, or fear of rejection. Will and Rick had the assertiveness and self-confidence to achieve this step. Rick explained,

> I was interested in medical robotics and so when I came here [to the university] there wasn't something specifically in that area … I got the robotics side of it covered when I was starting [a robotics competition] team here and then medical side … I started looking for research groups that could accomplish that goal and I thought that [Dan's] group was a really good fit … So I went and proposed working in that area to him.

This is remarkable behavior for a freshman, in terms of setting goals, organizing solutions, and convincing a professor to accept him into a lab. Will was similarly motivated as a freshman: "[Research] was something I really wanted to do, so I went out and tried to contact people and got involved as soon as I could." These undergraduates are very active and successful in Dan's lab, thanks in part to their willingness to contact a professor and join new communities.

Like Dan, Kate expects undergraduates to approach her for research work, and she also invites them to apply when her lab needs assistants. Frank asked to join her lab: "I really enjoyed [Kate's] class, so I decided to ask her for a research assistantship. It worked out." Jessie and Gretchen also met Kate in class, in a different semester than Frank. Kate emailed their class to advertise summer lab positions. Jessie told me, "I was like, 'Whatever, I'll try.'" It may be significant that the two women I studied were hired through a general invitation to apply, while the three men requested their lab positions. More men describe themselves as assertive than women do (Costa et al. 2001); therefore expecting undergraduates to request lab positions may disproportionately exclude women alongside less-assertive men. Inviting applications, or perhaps just informing students that professors expect them to ask for research positions, could potentially avoid this bias.

Once undergraduates join these two labs, they have very different experiences of socialization, a process Dan calls "onboarding". Will explained that when he first asked Dan to join the lab, "[Dan] was like, 'Okay, you can start coming to meetings and you can see if you can get involved.' And that was it for direction." Will had the confidence and tenacity to attend group meetings without having an assigned role in the lab's projects. He had to create his own role, by volunteering to do research tasks mentioned in the meetings. Dan explained this approach as:

> a sink-or-swim thing, where I invite them to come to meetings … to engage with the group and figure out a way to contribute and to identify a project, and that I'd be helpful with that but really I put the responsibility to them to work their way into the lab.

Most undergraduates drop out of the lab soon after they join. Perhaps they find inserting themselves into a community of strangers in an unfamiliar field too intimidating or unwelcoming. In comparison, undergraduates who join Kate's lab rarely leave. Kate assigns each undergraduate to a grad student, who trains them and gives them specific tasks. Undergraduates also meet with Kate one-on-one every week, to discuss their results, concerns, and future experiment plans. Thus both PIs expect students to initiate the conversation about joining a lab. Dan then expects students to define a role for themselves while Kate gives them a mentor.

Another aspect of lab work that the PIs expect undergraduates to be assertive about is organizing, scheduling, and documenting their lab work. For example, the undergraduates control when they work, as Frank explained:

> I usually work on the weekends … I just can't make it during the week because I have classes … I can't go to the lab for 30 minutes and do things [between classes], because everything takes a lot of time, and I'd rather be working at my own pace rather than being rushed and doing something wrong [laughs], which would be really bad and expensive.

Frank chooses to work on weekends, entering the lab with his own key as all the undergraduates do, to preserve the quality of his work, based on his own assessment of his abilities. Kate grants him and the other undergraduates the power to work as is best for them. Jessie acknowledges that this self-defined schedule doesn't work for everyone: "[If] I wasn't that self-motivated, I could just push off all my [lab] work and get away with it. But I want to be good." Undergraduates who need assigned schedules, explicit directions, and monitoring might struggle to succeed at lab work.

Finally, both PIs expect undergraduates to ask questions. This may seem like an easy and obvious ability; however, asking a question requires the asker to recognize their own confusion. This requires significant self-awareness. In addition, asking a question of a higher-status person, such as a grad student or PI, requires confidence and humility, as the asker risks being deemed stupid or incapable. Kate encourages students to ask questions:

> That's what I tell them right away, there's no bad question ... I also leave my door open as much as possible and I say, "If you have questions and we're not supposed to meet for five days, my door is open, just poke your head in, ask your question."

She sees question-asking as student-directed and efficient. She is happy to answer, especially to prevent wasting the student's time before the next meeting. Her open door is a concrete sign of her commitment to the common refrain that undergraduates hear but may not believe, that "there's no bad question".

Dan also values undergrads' assertiveness in seeking help and demanding attention. For example,

> [One undergrad] was really persistent. She communicated very well with me … Ultimately it was just a matter of having enough back and forth and creativity and just brainstorming where she got to that point of "Oh, here's this project that I'm really interested in that I can do" … I was really impressed how she came around to that.

This undergraduate overcame the challenge of defining a project through "persistent" communication with Dan. Having several substantive conversations with a PI about research sounds like a valuable educational experience. Dan's admiration for this student's pursuit of help on her project design suggests that it may be an unusual occurrence. After all, the student had to request and participate fully in those conversations. Many undergraduates would hesitate to articulate their concerns to a professor, because of intimidation, poor communication skills, and/or low self-awareness.

Conclusion: Opportunities for Exclusion

The characteristics that researchers value for future researchers shed light on whom they invite into research careers and on the skills and social norms students learn by participating in research communities. Specifically, these two engineering professors expect undergraduates to express enthusiasm and be assertive about lab work. PIs must select undergraduates somehow, to maximize the return on their investment of training and trust in students to handle expensive equipment and priceless data. I do not claim to know how to choose fairly; however, I suggest that we pay attention to how we select students for all professional and educational opportunities. It is a ripe occasion for unintentional discrimination, through mechanisms such as implicit bias (i.e., unconscious beliefs we have about groups of people) and homophily (i.e., a human preference to interact with people who resemble us physically or culturally).

It's possible that PIs' expectations of enthusiasm and assertiveness for lab workers disproportionately exclude students from underrepresented groups in science and engineering. Studies show that norms in science and engineering reflect white, middle-class, and masculine values, which can make students outside these groups feel unwelcome (National Academies 2016, 62). Moss-Racusin and coauthors (2012) conducted an experiment by sending science PIs an application with a male or female name for an undergraduate laboratory worker position, and the PIs—men and women—ranked the male-named application higher than the same application with a female name. Stereotypes and implicit bias about the characteristics of good researchers, such as this preference for men over women, are significant factors in choosing candidates at the undergraduate level as well as at the faculty level (e.g., Steinpreis et al. 1999). Part of the problem is that a large majority of the engineering students and faculty in the United States are men and/or white (Yoder 2015). Engineers who feel comfortable in the culture built by these majority-group practitioners are likely to thrive, while those who feel they don't belong, for any variety of reasons including gender and race, are more likely to leave (Seymour and Hewitt 1997; Fletcher 1999; Tonso 2007). Homophily suggests that professors select students who share their background, in terms of race, gender, class, culture, etc.; thus, professors' expectations for good lab workers may serve as inadvertent barriers to students from underrepresented groups. This idea matches how elite companies hire workers by "cultural matching," i.e., preferring candidates who share experiences, personalities, and behaviors with the search committee members (Rivera 2012).

Learning to express interest may be part of the socialization into today's engineering culture. Students who do not enact this behavior could be unfairly undervalued by PIs, with important implications for the students' careers and for future engineering practitioners. In addition, whether and how people express enthusiasm and assertiveness is culture-specific and influenced by socialization and stereotype threat. It's possible that an interested and assertive student may express these traits in ways that the professors do not perceive as interested and assertive. These mismatches in behaviors and expectations could unintentionally result in the selection of disproportionately fewer women and minorities as lab workers and, accordingly, as engineering majors and professionals.

This study's results inspire potential strategies to mitigate PIs' biases and thereby provide students with fair opportunities for professional development. First, PIs should be aware of their own assumptions, such as whether their perception of a student's enthusiasm or willingness to ask for a lab job accurately reflects that student's work ethic and ability. Acknowledging how we judge students is the first step to instituting strategies to promote inclusion. Second, universities should inform all students that PIs expect them to ask for lab jobs, to broaden the applicant pool beyond students with majority-group cultural capital. Accordingly, these two PIs' belief that grades do not reflect lab skill creates valuable opportunities for lower-performing students. Third, PIs should invite general groups of students, not selected individuals, to apply for lab jobs, to create welcoming opportunities rather than waiting for students to make requests. Perhaps PIs could lower barriers to joining a lab by training several undergraduates—thereby teaching them how to identify problems and ask for help—and then assessing their lab work as a criterion for continued lab work. Though more time-consuming than existing selection processes, this approach would give students the chance to develop abilities and interest. It seems more fair—and, logically, more predictive of research success—to evaluate students based on their lab work than on their behavior in an interview. Finally, universities should train all students to be assertive self-advocates and to develop professional skills. How to implement these strategies deserves further research.

Working in labs is a valuable way for students to learn desirable skills and behaviors for researchers. Likewise, working with students is a powerful way for PIs to train and socialize future researchers. Adopting strategies to reduce bias and promote inclusion could help PIs avoid overlooking potentially skillful future researchers, thereby broadening participation and diversity in engineering and science.

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[i] I consider the cultures of academic research in engineering and science to be comparable.

[ii] All names are pseudonyms.