

Broadening Participation in Online Research and Learning in Materials Science and Engineering: The Impact of Recruitment Strategies

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Abstract— This innovative practice paper describes how recruitment strategies affect both the educational backgrounds and the research interests of applicants to an online research and learning experience in the field of materials science and engineering (MSE). Focused on students from historically underrepresented backgrounds within U.S. undergraduate science and engineering programs, our study addresses a critical gap in extending the reach of online initiatives to applicants from a broad range of universities. While undergraduate research has been shown to be an important vehicle in increasing diversity and participation of students from historically underrepresented backgrounds in science, technology, engineering, and mathematics (STEM) careers, a large fraction of educational institutions remains out of the recruitment purview of Research Experiences for Undergraduates (REU) programs. This limitation arises in part from the conventional reliance of promotion mechanisms on established higher-education consortiums, limiting outreach to eligible applicants from schools beyond these networks or those in non-research-focused universities. To address this, we implemented innovative recruitment strategies, emphasizing direct personal engagement with STEM programs at minority-serving institutions (MSIs) and scholarship networks dedicated to underrepresented groups across the nation. Over three annual application cycles involving approximately 200 applicants, we traced the evolution of our recruitment tools and evaluated their impact on the academic backgrounds (e.g., major of study, undergraduate year, university) and MSE research interests reflected in the submitted applications. Compared to traditional REU recruitment strategies, our approach was found to result in a broader range of academic backgrounds without any significant difference in application quality (e.g., score on evaluation rubric). Furthermore, our findings reveal that applicants' research interests directly reflect altruistic broader impact goals related to MSE, aligning with documented trends in undergraduates from historically underrepresented groups enrolled in other STEM programs. Importantly, the insights derived from this study extend beyond MSE programming, offering guiding principles for implementing successful recruitment strategies to foster diversity in online research and educational interventions across disciplines.

Keywords—undergraduate research, remote laboratory, student diversity, recruitment and retention.

I. INTRODUCTION

In 2018, the American Society of Engineering Education reported that 16.3% of undergraduate engineering degrees were earned by students from historically underrepresented groups.[1] At the doctoral level, only 11.1% of engineering degrees were earned by minoritized students. Across all science, technology, engineering, and mathematics (STEM) fields, these students are the least likely to pursue graduate studies and, among those that do start a PhD degree, they are the least likely to complete it within ten years; degree completion is as low as 40% in some disciplines.[2] The discipline of Materials Science and Engineering (MSE) is no exception to this trend.[3] Recruitment and retention issues are exacerbated by the absence of MSE as an on-site undergraduate program at 55 of the top 100 best national universities; none of the top 50 historically black colleges and universities (HBCUs) offer MSE as a major (US News and World Report).[4] The lack of diversity in the STEM and MSE workforce hinders scientific advancement, which can have profound consequences as we seek innovative solutions to critical grand challenges for engineering, such as sustainability, health, and security.

The positive influence of undergraduate research experiences on guiding underrepresented science students toward graduate school and professional careers in STEM has been extensively researched.[5] Various existing research-focused programs, such as the Meyerhoff Scholarship program or summer research experiences for undergraduates (REUs), have demonstrated significant increases in enrollment of undergraduate participants in subsequent graduate studies and advanced STEM careers.[6] However, these initiatives face certain limitations. Their structure typically necessitates students to be on campus for over 40 hours per week (with at least 10 of these

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hours being dedicated to research), thus restricting the reach of the programs beyond the summer months or the students' home campuses. Additionally, recruitment strategies for summer REUs often rely on established networks of schools, limiting outreach to schools that may not prioritize research or offer limited STEM or MSE programming. Many REU programs are promoted through established networks of the National Science Foundation (NSF), such as the REU Sites program or, for MSE research, the Materials Research Science and Engineering Centers (MRSECs) program, which primarily involve research-focused institutions and a restricted number of minority-serving institutions (MSIs). Another prevalent advertising strategy hinges on the National Name Exchange (NNE), a consortium of over fifty universities that annually gather and exchange the names of their talented and underrepresented ethnic minority students. However, most NNE member universities are non-MSIs and/or have graduate schools, suggesting a strong inclination towards research-focused activities.

To address some of these obstacles, the Materials Initiative for Comprehensive Research Opportunity (MICRO) was established in 2021 as an online research and education program centered on materials science. [4] MICRO involves minoritized undergraduates from across the United States in a long-term, in-semester online experience by pairing them with a research group at one of the top two graduate MSE programs in the country: Northwestern University (NU) or the Massachusetts Institute of Technology (MIT). Participants conduct their own research projects online, for a time commitment of 12 hours per week, under the guidance of a research mentor and a faculty member. Since its inception, 195 undergraduates have applied to MICRO, with 20 selected students who have engaged in online research for one year or more, with the majority participating across multiple academic years.

Over three annual application cycles of MICRO, we examined the influence of recruitment strategies on the academic backgrounds (such as major of study, undergraduate year, and university) and MSE research interests reflected in the submitted applications. In this analysis, we demonstrate the efficacy of prioritizing direct personal outreach to STEM programs at MSIs and engaging with scholarship networks tailored to underrepresented groups nationwide. By employing these targeted approaches, we aim to broaden participation in MICRO and analogous undergraduate research programs. These strategies have the potential to draw in students from a broader spectrum of institutions beyond traditional recruitment circles, thereby augmenting the reach and positive impact of such initiatives on enhancing diversity in STEM and MSE research and education.

II. RECRUITMENT STRATEGIES

The promotional materials remained consistent across different advertisement channels and application cycles, encompassing: (i) a brief overview of the MICRO program, (ii)

a clear statement outlining the application timeline and deadline, (iii) a hyperlink to the program's website, and (iv) a detailed flyer highlighting the program's key components and advantages. These materials were distributed through the various channels outlined in this section. Table I summarizes which strategies were used together in any given application cycle.

TABLE I. YEAR-TO-YEAR MICRO ADVERTISEMENT STRATEGIES

Recruitment tool	Application year		
	2021	2022	2023
National Name Exchange (NNE)	X	X	X
Summer REU networks	X	X	X
Social Media Advertisement		X	X
MICRO participants and alumni network		X	X
Undergraduate scholarship programs		X	X
Direct Emails to MSI STEM programs			X
Minority-Serving Professional Societies			X

A. The National Name Exchange (NNE) Program

We utilized the dissemination list of the NNE, to which both MIT and NU contribute as participating institutions. This approach was consistently employed throughout each application cycle and served as the baseline recruitment strategy in tandem with distribution through the email list of partner summer REU programs.

B. Email List Distribution from Summer REU Programs

Each year, we collaborated with our summer REU partners at MIT and NU to promote the MICRO application cycle through the same email distribution lists they utilize for their respective programs. Staff members from the MIT Summer Research Program (MSRP) and NU MRSEC REU were provided with promotional materials and agreed to disseminate them within their advertising networks and to current students. This approach, coupled with the use of the NNE, helped to assess the influence of traditional advertising strategies on the demographics of undergraduate applicants.

C. Social Media Advertisement

In 2022 and 2023, the call for applications was also publicized on prominent social media platforms known for enhancing the visibility of academic programs, including Twitter and LinkedIn. These posts were made through Prof. Chazot's accounts. The tweet in 2023 received 5,000 views and 5 retweets, while the tweet in 2022 had 650 views and was retweeted once. On LinkedIn, the post in 2023 was viewed 5,495 times and reposted 9 times, compared to the 2022 post which had 4,399 views and was reposted 3 times.

D. MICRO Participants and Alumni Network

Following the inaugural year of MICRO, which saw the participation of 7 individuals, we strategically utilized the network of participants and alumni, enlisting their support in promoting the call for applications to their peers, classmates, and

broader communities. This initiative was repeated in MICRO's second year, which saw an increased participation of 10 individuals. Through this community-driven strategy, we were able to extend the reach of our recruitment efforts beyond NNE subscribers and recipients of summer REU emailing lists. Although the number of applicants influenced by word-of-mouth referrals remained modest (5-10 per year), this tactic proved instrumental in fostering deeper connections with scholarship programs, professional societies, and STEM programs in which participants were enrolled.

E. Undergraduate Scholarship Programs

In 2022 and 2023, we strategically promoted MICRO through undergraduate STEM scholarship programs aimed at historically underrepresented student populations in science and engineering. In 2022, MICRO's advertisement received support from prestigious programs such as the Meyerhoff Scholar Program at the University of Maryland, Baltimore County (UMBC) and the Karsh STEM Scholars Program at Howard University. These programs graciously agreed to share the application call with their cohorts of scholars. Additionally, in 2022, we collaborated with the IBM-HBCU Quantum Center, which encompasses 22 HBCUs, to disseminate the application call to their affiliated faculty and undergraduates.

Thanks to the support of our initial points of contact, we expanded our outreach efforts in 2023 to include a broader range of scholarship and undergraduate programs supporting minoritized undergraduates. This expansion included collaboration with the Dow SURE program, spanning across 5 HBCUs (Florida A&M University, Howard University, North Carolina A&T State University, Prairie View A&M University, and Southern University). Furthermore, partnerships were established with programs such as the Pennsylvania State University (Penn State)'s Millennium Scholars Program, the University of North Carolina (UNC) at Chapel Hill's Chancellor Science Scholars Program, the University of California (UC) at San Diego's PATH Scholars Program, and UC Berkeley's SEED Scholars Program.

Most of these scholarship programs are highly selective and require recipients to apply and engage in a minimum number of research-focused programs throughout their undergraduate studies. Leveraging this strategy enabled us to connect with exceptional applicants whose interests closely align with those of the MICRO program.

F. Direct Emails to STEM programs at MSIs

In 2023, to extend the reach of MICRO beyond institutions with established STEM scholarships and existing research infrastructures, we proactively reached out to 46 STEM programs at MSIs with identifiable distribution email addresses (e.g. faculty member, program director, or listserv contact), with a focus on 4-year public institutions. While we received responses from 9 out of these 46 emails, we also observed applications coming in from institutions that had not initially responded to our advertisement emails. This proactive outreach enabled us to broaden the scope of MICRO's reach to encompass a wider array of undergraduate MSIs, many of which do not carry research as a primary activity, or have smaller, newer STEM undergraduate programs.

G. Professional Societies for Minoritized Engineers

In 2023, we further capitalized on the support of MICRO participants, alumni, and mentors, many of whom hold active memberships or leadership positions in professional societies dedicated to supporting minoritized scientists and engineers. This enabled us to disseminate our call for applications across numerous professional society networks, including prominent organizations such as the Society of Hispanic Professional Engineers (SHPE), the National Society of Black Engineers (NSBE), and the National Society of Black Physicists (NSBP).

III. METHODOLOGY

Our study combined quantitative data such as home institution, graduation date, reported major, with qualitative analysis of answers to open-ended questions used in the selection process. We did not collect demographic data related to race, ethnicity, gender, or other social identities and therefore did not take these factors into consideration in the selection of participants.

A. Application Content and Evaluation

More details on MICRO selection process can be found elsewhere [4] but the main components relevant to this study are highlighted here. MICRO applicants were required to submit responses to the application questions, their CV, and their academic transcripts. The application was free, and a minimum of one letter of recommendation was highly encouraged but not required. In their applications, students were asked to answer the following open-ended questions:

- (1) What has motivated you to pursue a career in science or engineering?
- (2) What are your future educational and career goals? How do you think participating in MICRO will help you further these goals?
- (3) Why are you interested in developing competence and pursuing a research project in the field of materials science and engineering? In which domains of MSE would you be interested in pursuing research?

The complete application intake form is provided in Appendix I. Each application was then rated on a scale of 1 (Beginner) to 4 (Advanced) in each of four rubric categories: (i) Academic Performance, (ii) Research Potential, (iii) Research Experience, and (iv) Commitment to Community, Academics, and Research. A value of 0 on any of the rubric components indicates that the application lacked sufficient material for evaluation (e.g., missing transcript, CV, or sections of the application). The overall score was calculated by taking the average of the scores on each rubric section. The application materials and evaluation rubric remained unchanged throughout the three application cycles.

B. School Classification

MSIs and public schools were identified according to the publicly available list of postsecondary institutions accredited by the United States Department of Education Office of Postsecondary Education. For this study HBCUs and tribal colleges and universities (TCUs) were considered as MSIs, as defined by § 365(3) of the Higher Education Act (HEA) (20

U.S.C. § 1067k(3)) as institutions enrolling populations with significant percentages of undergraduate minority students. The presence of a dedicated MSE undergraduate major was determined using the data collected by the authors and described elsewhere. [4]

C. Coding Methods for MSE Research Interests

Semantical content analysis[7] was used to extract the research interests of MICRO applicants. The coding architecture was developed by identifying recurring words between responses to the relevant application question and recognizing emerging themes. Essays were first coded according to the applicants' interest in specific materials classes following six categories: (i) biomaterials, (ii) ceramics/glasses, (iii) composites, (iv) electronic, optical, and magnetic materials (EOM), (v) metals, and (vi) polymers. A second coding method grouped data based on the students' interest in specific interdisciplinary engineering challenges according to five categories: (i) computing, (ii) energy, (iii) health and medicine, (iv) manufacturing, and (v) sustainability. The most used words or types of words used to assign an application to each of these five grand challenges is given in Table II.

TABLE II. MOST USED WORDS USED TO CLASSIFY APPLICATIONS ACCORDING TO THEIR INTEREST IN ENGINEERING CHALLENGES

Category	Recurring words
Computing	semiconductor, quantum computing
Energy	nuclear engineering, photovoltaics, batteries
Health and medicine	drug delivery, prosthetics, tissue engineering, wearable technologies
Manufacturing	additive manufacturing, chips, metamaterials
Sustainability	Recycling, textiles, plastics, water purification, carbon capture

IV. RESULTS

The design of our study, incorporating additional advertisement strategies across each application cycle, allows us to assess the effectiveness of recruitment practices that prioritize direct engagement and relationship building with students, prestigious scholarships for minoritized undergraduates, STEM programs at MSIs, and professional societies. Specifically, our focus lies in analyzing data concerning the home institutions and undergraduate years of MICRO applicants, the overall quality of applications based on our evaluation rubric, and the STEM backgrounds and reflected MSE interests of prospective participants.

A. Classification and Home Institution of Applicants

Through quantitative analysis of MICRO applications, we examined how advertisement strategies influenced the total number of applicants, their distribution across undergraduate levels, and the representation of various school categories (Fig. 1). Specifically, we measured the proportion of applicants currently enrolled in institutions without an MSE-specific major, those attending MSIs, and those enrolled in public schools, tracking changes over three application cycles.

We observed that the advertisement strategy had minimal impact on the total number of applications, which remained consistently between 60 and 70, and did not significantly alter the breakdown of represented undergraduate classes (Fig. 1a). This may seem unexpected but can be attributed in part to the influence of the COVID-19 pandemic, particularly evident in 2021. During MICRO's first year, many institutions still restricted in-person access to campuses and research facilities for undergraduate researchers, prompting a surge in students seeking online research experiences like MICRO. Despite a return to in-person programming in 2022 and 2023, the number of applicants remained steady, underscoring the expanded reach of our advertisement strategy to audiences seeking long-term online research experiences. Moreover, the number of schools represented remained relatively constant across all application cycles, with 43, 37, and 42 different institutions reflected in applications in 2021, 2022, and 2023 respectively. Notably, the expansion of advertisement channels between 2022 and 2023 did not yield a significant increase in the total number of applicants, with 62 and 66 completed applications, respectively.

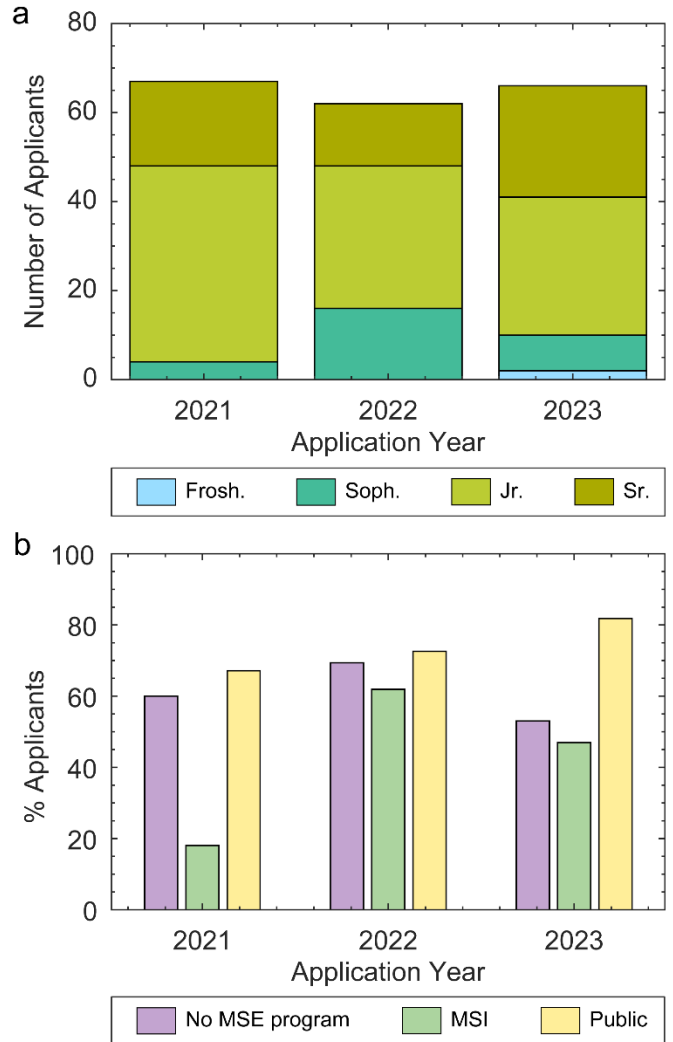


Fig. 1. Schools and undergraduate level representation. (a) Number of applicants breakdown per undergraduate class. (b) Evolution of the fraction of applicants coming from schools that do not offer MSE programming, MSIs, and public institutions with each application cycle.

In both 2021 and 2022, most applicants were sophomores (Soph.) or juniors (Jr.), with no freshmen (Frosh.) and only a small percentage of seniors (Sr.). This trend is partly because sophomores and juniors constitute the largest cohort of undergraduate researchers, possessing adequate experience and knowledge to engage in a research project while still having substantial time remaining in their undergraduate career to benefit from a long-term experience with MICRO, enhancing their research skills and professional networks before potentially applying to graduate programs. In 2023, we observed an increase in the number of senior applicants, along with two freshman applicants. We attribute this rise to the inclusion of clarifying information in the frequently asked questions section of our program website, where we addressed senior eligibility, stating: *“I am a senior graduating this upcoming year, am I eligible to apply? Yes! However, you will need to make a strong case in your application of why you would benefit from the MICRO program. This is important because graduate school applications are due very early during MICRO’s Fall semester and this can limit the positive impact the program has on improving your graduate school application package.”*

The expansion of advertising strategies had a profound impact on the representation of the three categories of schools of interest (Fig. 1b). In 2021, when the NNE and summer REU networks were the sole channels for promoting the call for applications, only 18% of our applicants came from MSIs. This number surged to 62% in 2022, with the vast majority of these students being STEM scholars or affiliated with relevant programs at MSIs that we actively engaged in recruiting. Additionally, 2022 witnessed a modest increase in the fraction of students coming from schools that did not offer MSE programming, rising from 60% to 70%. Although the number of

applicants from MSIs decreased to 47% in 2023, it remained substantially higher than in 2021. Despite the decline in the number of MSI applicants between 2022 and 2023, the diversity in school representation remained consistent, with 18 MSIs represented in 2023 compared to 16 in 2022. Among the 18 MSIs represented in 2023, seven were not included in the 2022 representation and were among those we contacted spontaneously via email that year. 2023 also saw a slight decrease in the fraction of applicants from colleges that do not offer a dedicated MSE major, dropping to 53%.

These trends suggest the greater impact of engaging STEM scholarship programs aimed to increase the number of underrepresented minority students who earn a graduate degree in a STEM discipline, compared to making spontaneous contact with STEM majors at many MSIs. Indeed, in 2023, we expanded our advertising efforts to include minority-focused scholarship programs in public R1 institutions that already featured MSE undergraduate programming (e.g., Penn State and UC Berkeley), resulting in a substantial increase in the number of applicants from these schools. Moreover, engaging professional societies resulted in spreading the call for applications beyond MSI networks: for example, 53.5% of SHPE undergraduate students in STEM want to achieve a master’s or doctoral degree,[8] making them more inclined to pursue a bachelor’s degree in a research-focused institution. This broader engagement is further evidenced by the consistent rise in the fraction of applicants from public institutions, increasing from 67% in 2021 to 73% and 82% in 2022 and 2023, respectively.

Overall, our consistent number of received applications, despite a return to in-person activities following the COVID-19 pandemic, and the increased proportion of applicants from MSIs and public schools, underscore the success of our advertising

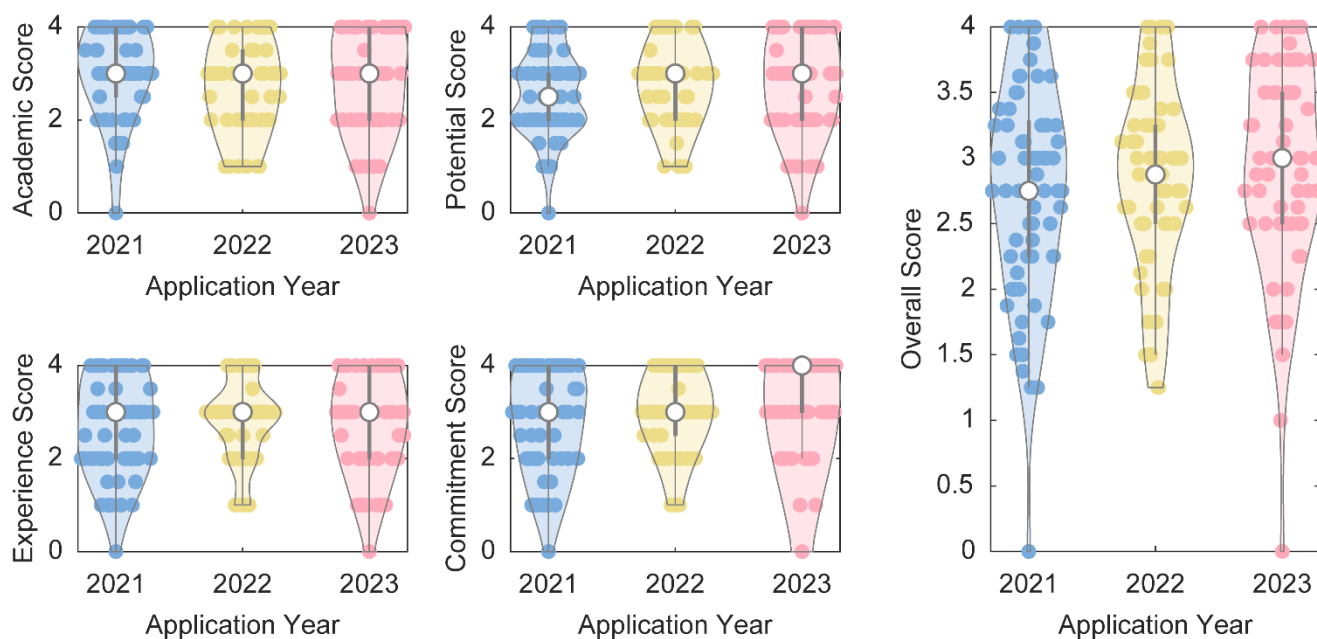


Fig. 2. Violin plots illustrating the distribution of scores for each component of the evaluation rubric and the overall score across application cycles. Each application was assessed on a scale of 1 (Beginner) to 4 (Advanced) across four rubric categories: (i) Academic Performance, (ii) Research Potential, (iii) Research Experience, and (iv) Commitment to Community, Academics, and Research. For reference, admitted students scored on average between 3.8 and 4 on each section of the rubric and overall (total of 22 admitted students - 6 in 2021, 7 in 2022, and 9 in 2023).

strategy in reaching beyond the traditional circles of summer REUs and the NNE.

B. Application Quality

Along with the increased representation achieved by our advertising strategy, we observe minimal variation in the overall rating of applications according to our standardized rubric across different years (Fig. 2). Notably, applicants consistently scored highly on the academic component of the rubric, with an average hovering around 2.7/4, showing little correlation with academic year. This suggests that academic excellence, as reflected by GPA, is rarely a distinguishing factor for successful applications. Instead, research potential and experience emerge as the primary determinants for selection. While research potential stood out as the most critical factor in 2021, as evidenced by its multimodal score distribution, research experience became more decisive in 2022.

The rise in the number of MSI participants between 2021 and 2022 led to an overall increase in research potential scores, while the average research experience score remained mostly constant. This increase in research potential stems from a higher frequency of students scoring in the highest bracket, driven by factors such as a strong desire to pursue advanced graduate degrees, clear articulation of long-term goals, and involvement in academic preparatory programs (e.g. McNair and other STEM scholarships). The lower frequency of very high research experience scores (i.e. 3.5/4 or greater) in 2022 can be attributed to the broader representation of students, not exclusively from research-focused undergraduate institutions. Indeed, rubric requirements for the highest score include engaging in 1 or more years of research and having presented at a research conference and/or authored a publication (in preparation or submitted).

In 2023, the increased representation of STEM scholarship programs at R1 institutions resulted in a resurgence of high research experience scores, alongside a substantial fraction maintaining top research potential scores. Moreover, the commitment scores of applicants increased compared to 2022 and 2021, with many scoring 4/4 in this rubric section. This shift indicates a strong commitment to community and diversity, evidenced by applicants' engagement in mentorship and leadership roles in professional societies, likely influenced by our advertisement strategy.

C. STEM Background and Interests

Examining the undergraduate majors and expressed research interests of our applicants yields valuable insights into their overall background and ambitions. The predominant engineering and science majors represented across all application cycles, along with their respective proportions of applicants, are depicted in Fig. 3. Notably, chemical engineering (ChemE), biological engineering (BioE), and mechanical engineering (MechE) emerged as the most prevalent majors in engineering, while chemistry (Chem), biology (Bio), and physics showed representation above 5% in science disciplines. Intriguingly, 2022, which had the highest representation of schools without MSE programming, also boasted the highest proportion of applicants declaring pursuit of a bachelor's degree

in MSE (10% compared to <5% in 2021 and 2023). Additionally, a noteworthy trend is observed in the balance between engineering and science majors: while 2021 and 2022 exhibited a relatively equal distribution, 2023 witnessed a significant surge in engineering undergraduates alongside a decline in science majors.

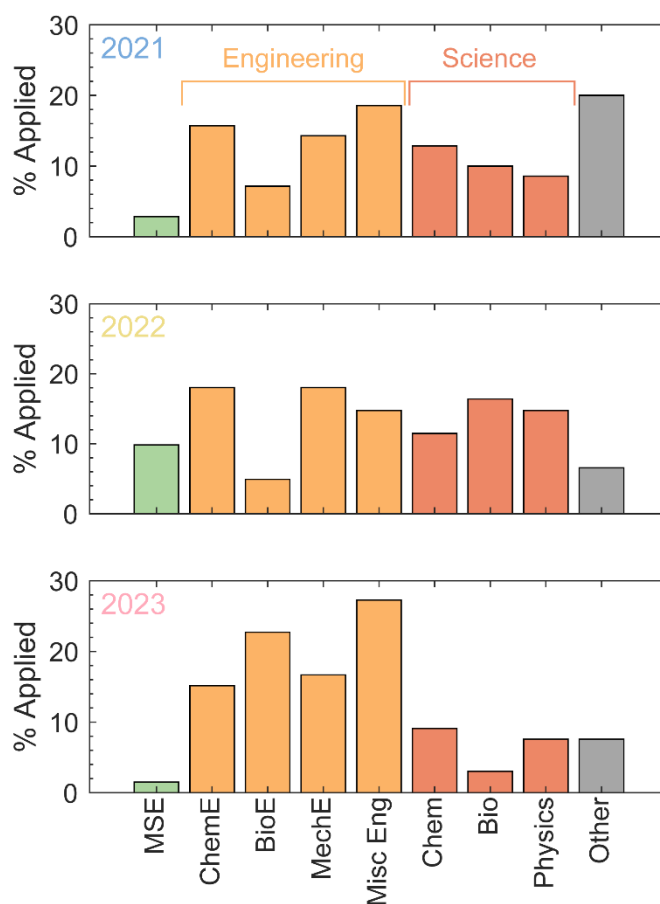


Fig. 3. Representation of undergraduate majors in the applicant pool across application years. The primary engineering and science majors are illustrated, while majors other than MSE, comprising less than 5% consistently, were categorized as "Misc Eng" for engineering majors and "Others" for science and non-STEM majors.

Analysis of the applicants' responses to the open-ended essays allowed us to identify major research fields of interest, grouped either according to category of materials or engineering grand challenge (Fig. 4).

Regarding the categories of materials that piqued the interest of MICRO applicants, "biomaterials" and "EOM" consistently emerged as the top two choices attracting the most applicants each year (Fig 4a). Interestingly, in 2023, there was a notable uptick in interest for "composites" and "ceramics/glass," both categories not represented in the previous year. Significantly, these material categories were largely discussed in the context of their significance for energy storage and harvesting applications, such as fuel cells and wind power. The expressed interest in "polymers," however, decreased between 2022 and 2023. This could potentially be attributed to the higher representation of engineering students and the overall breakdown of majors observed in that same year, as soft

materials are often prominently discussed in chemical engineering and chemistry curricula.

Every year, most MICRO applicants listed “health and medicine” and “energy” as their main areas of research interest (Fig. 4b), in alignment with the high attraction for “biomaterials” and “EOM”. These findings also agree with reported evidence that minoritized students are more strongly motivated by altruistic and collectivist motives in their research interest, and more strongly prioritize the desire to work for social change and towards other externally focused values.[9], [10], [11], [12], [13] Likewise, first generation students have also been shown to have a greater interest in science when they feel the work has a prosocial communal purpose.[14] The students’ preferences may also reflect their desire to reduce environmental injustice affecting groups with one or more social identities they relate to (e.g., race, income, disability, gender, age, and/or nationality), who have been bearing a disproportionate share of the negative environmental consequences of technology development and deployment.[15] However, in 2023, we also noted a clear decline in interest in “sustainability” (perhaps related to the lower interest in “polymers”) and a rise in interest in “computing,” potentially reflecting national research priorities and increased investments in research. This trend underscores the primary motivational factors driving MICRO applicants to engage in MSE research, ranging from altruistic motives to a growing enthusiasm for contributing to cutting-edge innovation in areas of national importance.

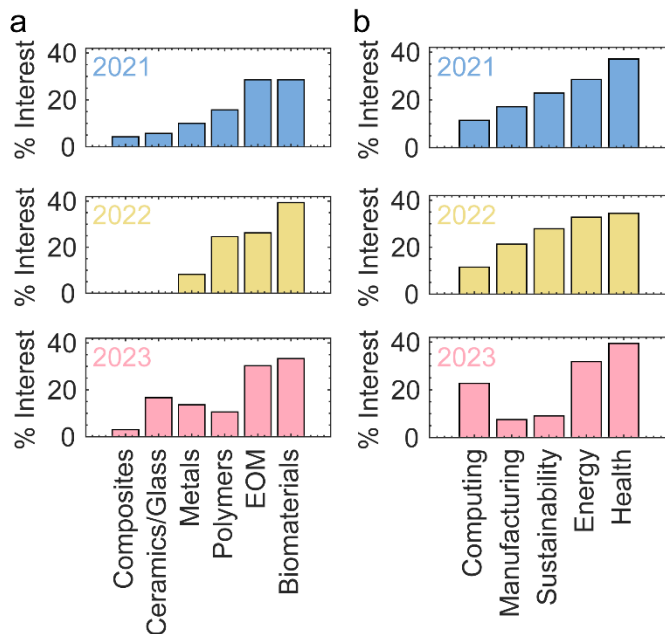


Fig. 4. Distribution of applicants' interests: (a) interest in specific materials classes. (b) interest in categories of engineering grand challenges.

V. DISCUSSION

While our advertising approach succeeded in broadening participation in MICRO, it also highlights several areas for improvement and future directions to enhance the involvement of minoritized undergraduates in research-focused programs. It is essential to recognize that spontaneous outreach to MSIs lacking specific STEM scholarship programs and a

strong emphasis on research activities yielded only moderate success in attracting applicants from these institutions. This underscores the need for research programs like MICRO to rethink their advertising narrative, beyond the use of numerous dissemination channels. Moreover, it underscores the importance of considering meaningful changes to program formats and components to appeal to a wider range of applicants beyond those already highly motivated to pursue advanced graduate degrees. For example, incorporating additional in-person components, and involving MSE research institutions beyond NU and MIT could significantly boost student engagement. These in-person elements could be utilized in advertising, like participating in graduate school fairs at local institutions, and in the program itself, such as facilitating research collaborations between students' home institutions and their MICRO faculty mentors. Furthermore, beyond simply improving recruitment of minoritized undergraduates into research programs and subsequent graduate studies, we must also prioritize providing long-term support to these students and fostering a sense of belonging in STEM disciplines. This is crucial for breaking the cycle of underrepresentation, which often reinforces solo status and stereotype threat,[16] ultimately impacting individuals' creativity, performance, and career trajectory.[17], [18]

VI. CONCLUSION AND OUTLOOK

In conclusion, this innovative practice paper sheds light on the pivotal role of recruitment strategies in shaping the educational backgrounds and research interests of applicants to an online research and learning experience in MSE. Our findings underscore the limitations of conventional promotion mechanisms and highlight the effectiveness of prioritizing direct personal engagement with scholarship networks dedicated to underrepresented groups and STEM programs at MSIs nationwide. Our approach yielded promising results, broadening the range of academic backgrounds without compromising application quality. Furthermore, our research reveals that MICRO applicants' research interests closely align with altruistic broader impact goals and engineering grand challenges, emphasizing the urgent need for greater representation of historically underrepresented groups in STEM and MSE careers. As we strive for innovative solutions to critical engineering challenges, it is essential to harness the talents and perspectives of diverse communities. Importantly, the insights derived from this study extend beyond MSE programming, offering guiding principles for implementing successful recruitment strategies to foster diversity in research and educational interventions across disciplines. By leveraging direct engagement with MSIs and targeted outreach to underrepresented groups, institutions can enhance inclusivity and broaden participation in valuable research opportunities, ultimately contributing to a more diverse and dynamic scientific community poised to collaboratively tackle global challenges.

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APPENDIX I: MICRO APPLICATION ONLINE FORM

The main questions in the MICRO application online form used to collect the data used in this study and administered through Qualtrics are highlighted below:

Q1: The eligibility criteria below are required to participate in MICRO. Please confirm that you meet all the criteria listed below:

- *I am currently enrolled full-time in a degree-granting program (e.g. undergraduate, community college).*
- *I am a sophomore, junior, or non-graduating senior.*
- *I am authorized to work in the United States.*
- *I am interested in a research career and/or plan on pursuing a PhD in a STEM field.*

Q2: Name

Q3: Email Address

Q4: Mailing Address

Q5: University/College

Q6: Field of Study/Major

Q7: Anticipated Graduation Date

Q8: What has motivated you to pursue a career in science or engineering? (250-word limit)

Q9: What are your future educational and career goals? How do you think participating in MICRO will help you further these goals? (500-word limit)

Q10: Research in Materials Science and Engineering (MSE) takes place across a wide variety of key areas. These include biomaterials, materials for energy and sustainability, electronic and optical materials, metallurgy, among others. You can read more about the research going on in MIT and NU's materials science departments at <https://dmse.mit.edu/> and <https://www.mccormick.northwestern.edu/materials-science/>, as well as on the website of individual faculty members. Using this information: Why are you interested in developing competence and pursuing a research project in the field of materials science and engineering? In which domains of MSE would you be interested in pursuing research? (250-word limit)

Q11: Is there anything else that you would like to tell us? This is the place where you can highlight anything that you think is important in understanding your application package (e.g. a particularly low grade in your transcript, why as a senior you think you could benefit from MICRO) (250-word limit)

Q12: Please upload your resume or CV in pdf format here.

Q13: Please upload your transcript in pdf format here.