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Insights and Strategies for Improving Equity in Graduate School Admissions

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Summary

Applying to graduate school can be particularly challenging for students from historically minoritized backgrounds due to a hidden curriculum in the graduate admissions process. To address this issue, a team of volunteer STEM trainees established the Científico Latino Graduate Student Mentorship Initiative (CL-GSMI) in 2019 to support applicants from historically minoritized backgrounds. CL-GSMI is designed to improve access to critical resources, including information, mentorship, and financial support, and has assisted 443 students in applying and matriculating to graduate school. Using program evaluation data from 2020 and 2021, we highlight areas in graduate school admissions that can be improved to promote equity and inclusion.

Introduction

A major milestone for an aspiring scientist is being admitted to graduate school. Given that U.S. graduate school student bodies do not represent the diversity of the population, graduate school admissions therefore serve as a *de facto* bottleneck for diversity in science, technology, engineering and mathematics (STEM), perpetuating inequities in the constitution of future generations of scientists. Although some progress has been made in recent decades, the recent U.S. Supreme Court decision banning race-based affirmative action will further impede the representation of minoritized scientists in higher education and professional careers in the sciences for generations to come[95].

In this Perspective, we review literature and factors related to inequity in STEM higher education and then go into detail about strategies spearheaded by the authors and other team members of the Científico Latino Graduate Student Mentorship Initiative (CL-GSMI) to support students from all minoritized backgrounds and help counteract disadvantages we have observed that they face during the graduate school admissions process.

STEM graduate programs do not represent race and ethnicity demographics of the population of the United States

The number of students from historically minoritized communities in STEM graduate programs does not represent the demographics of the United States. As of 2020, 18.2% of the population is Hispanic or Latine (a gender neutral term for individuals of Latin American heritage)[1,2]. Among U.S. citizens and permanent residents, Hispanic or Latine students receive 17% of bachelor's degrees in science and engineering but only 9% of doctoral degrees[2,3]. Black and African Americans represent 12.6% of the U.S. population but only 7% of doctoral recipients[1,2]. According to National Center for Science and Engineering Statistics, 0.4% of doctoral recipients identified as American Indian or Alaska Native, relative to 0.8% of the national population[1,3]. Similarly, Native Hawaiians and Pacific Islanders represented 0.1% of the same doctorate recipients, relative to 0.2% in the general population[1,2]. Several available data sources have more granular information on demographics, fields, and degrees over the past several decades[1–4].

Relative to the United States population, the representative number of doctoral degree awardees from historically minoritized backgrounds has changed only modestly over the past 20 years[5,6,7] .

The “leaky pipeline” — excluding students from historically minoritized backgrounds from STEM professional careers

Academia has a long-standing diversity problem. Along the scientific career track, the decreasing representation of students from minoritized backgrounds is known as the “leaky pipeline”[8,9]. The leaky pipeline is complex, multifaceted, and relevant at all levels of academic career stages, extending from before a student begins their undergraduate education to after the attainment of a research faculty position[10–12]. There is a pressing need to address this underrepresentation gap, not only for reasons of equity and justice. Diversity also brings intrinsic value to science, such as societal and translational benefits, as well as scientific advancement itself[13]. For example, recent studies have shown that minoritized scientists innovate at higher rates, supporting an evident need for diverse viewpoints[14].

Common features that contribute to the leaky pipeline at every stage include ineffective evaluation and metrics of performance and scientific potential[15–19], social[20–22] and cultural factors[23–25], financial barriers[26–28], and systemic racism[29,30,93] (for example, microaggressions[31–33] and discrimination[31,33,34]). These features accompany and can augment psychological factors for students from minoritized backgrounds such as self-efficacy[21,35,36] (the belief that an individual is capable of accomplishing their goals), imposter syndrome[25,31,33], and, ultimately, motivation towards STEM careers[8,11,12,37].

A prospective doctoral or master’s student from a minoritized background confronts many, if not all, of these obstacles when applying or considering applying to graduate school[38–42]. Each of these factors impacts access to critical information, quality of mentorship, and the professional and research experiences necessary to succeed in applying to STEM graduate programs. Altogether, this often results in students lacking adequate support, as well as familiarity or resources, to uncover the “hidden curriculum” of applying to graduate school. This lack of support may lead them to undergo an unsuccessful admissions cycle (not receiving offers or matriculating) or even renege their decision to pursue graduate school applications at all.

We hypothesized that direct intervention and support to a student while applying to graduate school might help alleviate some of these disadvantages. Here we outline the intervention strategies we developed through CL-GSMI to equip graduate school applicants with the tools, information, resources, and support to provide them with a better chance of succeeding in their pursuit of STEM higher education.

As with many other points in the academic pipeline[10,43–46], outreach efforts have been a way to help disadvantaged students with graduate school admission[47–49]. These include research opportunity and funding programs such as Bridges to the Baccalaureate Research Training Program, Postbaccalaureate Research Education Program (PREP), and Louis Stokes Alliance for Minority Participation (LSAMP), as well as application assistance programs (AAPs) like CL-GSMI. By targeting graduate school applicants, AAPs are a

powerful and precise method for increasing the representation of minoritized groups in the sciences. These interventions can have a high impact on career outcomes and in remedying the discrepancy between the social and cultural expectations of students and graduate school admissions committees.

In 2019 and in collaboration with other undergraduate, postbaccalaureate, graduate students and postdoctoral scientists, the authors of this Perspective began developing the Científico Latino Graduate Student Mentorship Initiative (CL-GSMI) specifically to support graduate student applicants from minoritized backgrounds[50]. Based on our first-hand experiences navigating graduate school admissions, we discerned graduate school admissions as a distinct period of historically marginalized scientists' careers where we could provide significant intervention through organized peer support.

CL-GSMI is a unique AAP in that it is institutionally independent, completely trainee- and volunteer-run, large-scale (with at least 100 participants each year across multiple STEM fields), and focused on peer-mentorship dedicated specifically to and during the graduate school application cycle. One-on-one mentorship is a central resource that the program offers. It is made possible by 500 volunteer mentors, including graduate students, postdoctoral scientists, and faculty members from over 100 universities across the United States. We have assisted 443 students to date in applying and matriculating to graduate programs, and here we provide data from CL-GSMI from 2020 and 2021.

Based on educational research, which we review throughout this Perspective, our personal experiences, and that of our peers and previous mentees, we targeted three drivers of inequity in the graduate school application process. We designed CL-GSMI to improve access to (1) information, (2) mentorship, and (3) financial support. We expand on each in the sections below and discuss the strategies we employed to equip CL-GSMI graduate school applicants with a better chance of success in this critical moment of their STEM careers. Over the years, we have refined and improved our strategies, and CL-GSMI continues to evolve. Since our initial iteration of CL-GSMI in 2019, implemented improvements include regular check-ins on both mentors and mentees, acquisition of fee waiver partners, mock interviews, educational webinars, and expansion of the CL-GSMI document repository of example statements and curriculum vitae. We also expand on feedback CL-GSMI has received from mentors and participants and discuss other areas of planned improvement.

Our goal in this Perspective is to communicate our scalable strategies for supporting graduate school applicants (and their mentors), observations of the unique obstacles minoritized students face in applying to graduate school, and suggestions for how research institutions can make the STEM graduate school admissions process more equitable.

Broad efforts to recruit minoritized graduate school applicants

We encourage students from historically minoritized backgrounds to apply to CL-GSMI. In assessing participants, we consider disability status, ethnicity, status as first-generation college students, gender identity and modality, immigration status, sexual orientation,

socioeconomic status, and other applicant demographics. The data discussed in this paper was collected from 2019 to 2021 as part of CL-GSMI program evaluations (program evaluations are not subject to review by an Institutional Review Board and do not qualify as research under 45 CFR 46.102). During this time the sole eligibility criteria for acceptance to CL-GSMI was that students were applying to graduate programs in the sciences during the active graduate school application cycle (master's or doctoral programs) and self-identified as "underrepresented".

The CL-GSMI program has run from August to April for three years, from 2019 to 2021. The program is ongoing and after a one-year hiatus was relaunched for 2023. Students are recruited in a nationwide outreach effort before each year's program. We contact deans and department chairs serving at undergraduate institutions (particularly from minority-serving institutions) in addition to using Científico Latino social media platforms (e.g., Twitter, Instagram) and email listservs.

In efforts to reach applicants from minoritized backgrounds, we also contact coordinators for postbaccalaureate programs, summer research programs for undergraduates, Maximizing Access to Research Careers (MARC), and Research in Science & Engineering (RISE) programs. In the discussion, we address differences between approaches employed by CL-GSMI and those of other preparatory and bridge programs. A fraction of CL-GSMI applicants had previously participated in other preparatory initiatives (27.58% in 2020; 8.88% in 2021) (Table 1). These students' voluntary participation in multiple programs suggests the need for supplementary support, at least for some individuals, during graduate school admissions. This also indicates that the CL-GSMI resources and assistance are complementary to other initiatives.

To date, the CL-GSMI mentorship program has assisted 443 applicants to matriculate into graduate school programs in the sciences (Table 2). Official CL-GSMI participants completed their applications to graduate school and engaged with program milestones (e.g., attending one obligatory virtual meet-and-greet with the CL-GSMI team before being matched with their mentor). The majority of CL-GSMI applicants self-identified as women (68% in 2020; 59% in 2021), as coming from low-income backgrounds (65% in 2020; 67% in 2021), and were from traditionally minoritized backgrounds (Table 3).

CL-GSMI program structures to provide multifaceted support

Graduate school applications are thoroughly enigmatic to those outside of the academic sciences. As a result, the application process must be "demystified" each year to be accessible to certain groups of students[48,51–54]. To succeed, applicants must satisfy the expectations and challenges of the different components of the application, which is difficult without direct guidance from mentors. Admissions committees often assume applicants will receive detailed application guidance from mentors in labs where they have conducted research. However, this is often not the case for students from disadvantaged backgrounds. Furthermore, research mentors may not have the necessary ability or bandwidth to transmit the required institutional knowledge about norms and expectations of academia that exist outside of the lab but that is required for students to succeed in graduate school

applications[55]. Without proper encouragement and guidance, many of these students will apply unsuccessfully[54]. In other cases, some students that initially pursue graduate school eventually decide not to apply — not because of a lack of talent or interest in research, but because they do not see it as a viable option given their experiences and available resources.

Overall, participating graduate school applicants indicated satisfaction with CL-GSMI with an average score of 4.8 out of 5 in 2020 and 2021, demonstrating CL-GSMI was beneficial (Table 4). Some representative testimonials:

> "This program is a life saver! It literally changed my life by helping me with the process and now I'm going to be a Doctor! THANK YOU!"
>
> "Being the first in the family to pursue a Master's is difficult & Científico Latino helped me every step of the way. Beyond grateful!"
>
> "prior to doing GSMI, i [*sic*] had no frame of reference for graduate school applications, since very few of my peers applied and those that did were in different fields from me. It was helpful to have a database of personal statements, statements of purpose, and CVs to format mine after."
>
> "The helped [*sic*] I received did really shape my application to a winning one."

To grant access to essential information to graduate applicants in the CL-GSMI program, we rely on five primary tools: 1) one-on-one mentorship, 2) online resources, 3) educational webinars, 4) access to a global professional STEM network, and 5) mock admissions interviews (Figure 1). Other logistical features of CL-GSMI, such as timelines for applicants and mentors, and volunteer organization structure, are illustrated in Figures 2 and 3.

One-on-one mentorship is a critical resource for personalized guidance

A central component of CL-GSMI involves volunteer scientists as dedicated, one-on-one mentors to each applicant. Quality mentorship positively impacts a student's self-efficacy[37,56–58]. However, factors related to minoritized backgrounds, such as ethnicity, gender, and socioeconomic status, have a debilitating effect on academic relationships[20–22,59]. Furthermore, according to Smith, it is more difficult for mentors to transmit "higher degree" skills, such as cultural and social capital in understanding academic behaviors, expectations, and norms, than for features more typical of scientific mentorship[55]. These "higher degree" skills are necessary to navigate graduate school admissions. Therefore, we postulated that with the opportunity for individualized mentorship dedicated to helping applicants understand the academic norms and expectations of graduate school, applicants might be better suited to reach their potential during the admissions process.

The CL-GSMI pool of volunteer scientist mentors consists of PhD students, postdoctoral scientists, faculty members, and industry scientists (Table S1). CL-GSMI mentors serve as informal guides. They provide feedback on application materials and act as a sounding board throughout the application process, answering the student's questions and helping them to strategize solutions to individual challenges. Additionally, these mentors aim to empower and encourage the students, and hopefully develop a long-standing professional relationship

with them. Over the past three years, over 500 scientists from diverse backgrounds across the U.S. have served as mentors for CL-GSMI applicants (Table S1 and S4).

Applicants are hand-matched with a mentor by the CL-GSMI team. We prioritize matching applicants to mentors with a similar scientific field of study and immigration status during the application process, which typically comes with unique challenges (more in discussion on international and undocumented applicants). We also prioritize demographic information when possible (e.g., a similar minoritized background). In addition, we allow applicants to indicate any priority features for them when being matched with a mentor, including but not limited to race and ethnicity, gender identity, identifying as LGBTQIA+, and familiarity with non-U.S. graduate school admissions.

We provide additional details about CL-GSMI's process for selecting and preparing mentors below in the section on Mentorship: Screening and Guidance for Mentors for Minoritized Students.

Online resources and example applications help digest application challenges

CL-GSMI provides students with detailed information on the application process and components, curated on our website, which is freely accessible. It is critical for applicants to have free-of-cost access to multiple successful personal, research, and (if applicable) fellowship statements as relevant to their specific field as possible to understand the expectations for each. Since 2019, we have hosted 48 example personal statements, in addition to CVs, fellowships, and other materials, due to the generosity of our scientific peers and volunteer mentors. Additionally, we develop various guides, such as a suggested timeline for completing application components, compilations of tips on approaching each component, and tailored resources for applying as an international student.

We find hosting a centralized resource page simplified coherency, ease of use, and access to resources for CL-GSMI participants. This also enables us to tailor and update resources for CL-GSMI's specific audience. We also acknowledge that similar resources already exist in some of these cases, hosted by many others on the internet, and each resource brings a unique perspective. We curate external resources on our website and also host non-CL-GSMI team members' voices in the Científico Latino blog series.

Educational webinars allow for discussion of nuance and mitigating confusion

Webinars make the transfer of information interactive and accessible — a vital tool given that CL-GSMI applicants reside across the U.S. and abroad. We provided eight to ten individual webinars per application season, many of which are open to the public and are recorded and uploaded to the Científico Latino YouTube channel.

These webinars include "Overview of the Graduate School Application Process", "How to Apply to Graduate School as an International Student", and "How to Write an Effective Personal Statement". We also provide webinars on specific fellowships such as the National Science Foundation-Graduate Research Fellowship Program (NSF-GRFP) and Ford Predoctoral Fellowship. Additionally, we deliver discipline-specific webinars, such as how to apply to graduate school in chemistry, physics, or clinical psychology, to provide

context for field-specific expectations, which are at times remarkably disparate. Tailoring webinars to particular STEM fields and fellowships allows applicants the opportunity to ask panelists questions on specific challenges or points of confusion, interact with graduate students from different institutions, and make more informed decisions on how to best approach their application process.

Professional virtual network for crowd-sourcing unique or complex challenges

Creating a network of scientists and peer applicants using the messaging app Slack proves another crucial way of communicating information to CL-GSMI participants. By providing applicants access to the broader CL-GSMI community of mentors, volunteers, and other applicants, CL-GSMI participants have a more expansive support base with which to discuss challenges, ask questions, or share resources. For unique or particularly difficult challenges (e.g., a primary research advisor refusing to write a letter of recommendation), a sounding board or multiple perspectives from experienced academics can provide reassurance and help the student arrive at the best possible solution for navigating the situation[57,60,61].

Mock graduate school interviews necessary for feedback on academic etiquette

Each year, many CL-GSMI applicants apply to programs in the biological sciences (Table S2). For many of these programs, departments invite applicants for in-person visits. During these visits, applicants are evaluated in three to five faculty interviews before being offered admission. Faculty ask applicants about their scientific background, interest in the graduate program, and career goals[62]. Applicants sometimes do not know that preparing for these interviews involves practicing how to communicate their work and researching the work of the faculty interviewers. Peer workshopping can help improve this[94].

To address this, we offered a mock interview program to CL-GSMI applicants. Applicants received a guide on preparing for the interview process, including questions to expect, and were interviewed by at least two volunteer CL-GSMI mentors. Mentors were provided a rubric for constructive feedback on their applicant's interview etiquette and performance. Through this branch of CL-GSMI, applicants were able to practice their communication skills and understand good interview etiquette ahead of their graduate school interviews.

Through these centralized tools, 1) one-on-one mentorship, 2) online resources, 3) educational webinars, 4) access to a global professional STEM network, and 5) mock admissions interviews, we helped CL-GSMI participants tackle the application components.

Information: Increasing accessibility to the expectations around graduate admissions

Certain stages and components of graduate school admissions are particularly ambiguous or challenging. We sought to tackle them directly.

For example, the "professional" personal statement is an unfamiliar format for many applicants. Graduate school applicants must write a personal statement conveying their passion and motivation for pursuing a scientific career. They must discuss the extent of

their contributions in advancing a research project while discussing their scientific and professional growth in each research experience. Students must also describe how their experiences, skills, and interests fit each graduate program[51].

Most undergraduate students have never seen this type of personal statement. Moreover, women, and racial and ethnic minorities, tend to lack confidence in presenting their accomplishments compared to their white male peers[63–65]. In CL-GSMI, we break down the goals and expectations of the personal statement each year through webinars, guides, reminders, and examples of successful statements.

CL-GSMI mentors provide individual feedback on the personal statements of their matched applicants. We developed a process for selecting mentors, which is described in the Mentorship section, through which we choose mentors who are aware of the issues minoritized students might face. Through the selection and support of the CL-GSMI mentors, they are better prepared to provide the supportive advice that participants need as they draft their personal statement. Several mentors also volunteer to review additional personal statements of students who requested further feedback.

Below we present some of the obstacles minoritized students face, which CL-GSMI mentors are prepared to discuss with their mentees.

Challenges related to addressing personal circumstances which might be perceived as an applicant's weakness

Research experience and publications are key to a successful personal statement[16]. However, many students from minoritized backgrounds are often first-generation college students and/or from low-income backgrounds, requiring them to work throughout their undergraduate tenure to support themselves financially. Undergraduate researchers are rarely paid, causing these students to choose between financial responsibilities and their dedication to science[42,48,66]. This may result in students having limited remaining bandwidth to volunteer in a research setting throughout their time in college, leaving students who face these circumstances with less research experience. Moreover, during their first few years of college, many minoritized students may not be aware of what a PhD is, thereby delaying the process of building a competitive resume. Ultimately, their lack of research experience will make them appear less competitive in graduate school applications, or may even dissuade them from applying[48,67].

Research experiences are the best way for a student to connect with a scientific mentor. A research mentor is, in essence, a lab advisor or colleague who can answer questions on pursuing graduate STEM studies. As a result, students might not have the opportunity to create or develop this long-term connection with someone who is invested in and can guide them in their career choices.

Additionally, minoritized students may not have taken a traditional trajectory to the academic sciences. Socioeconomic or personal situations during their undergraduate tenure can interfere with academic or research obligations[23]. For example, students might have taken a semester off to save money for tuition or help care for younger siblings at home.

When students try to simultaneously handle these significant personal situations while also attending college, their GPA might suffer. Applicants who take non-research-oriented gap years to care for familial or financial issues may be unfairly penalized when their applications are evaluated[17].

In reality, certain experiences might better prepare a student for graduate school, such as multi-tasking or exhibiting dedication to science. However, admissions committees often view these as deficiencies, especially when compared to a more traditional student who may have been able to spend more time in the lab and, as a result, have more publications. Even for the most academically-inspired applicants, it is challenging to prevent the admissions committee from evaluating applicants who have had to address the above issues as non-competitive or under-prepared for graduate school.

As a result, minoritized students face the additional challenge in graduate school applications of needing to strategize and execute an approach to both overcome perceived weaknesses and demonstrate their strengths. Students of all backgrounds need the appropriate guidance and support from professors, mentors, or peers to develop a nuanced understanding of the expectations and possible impressions of graduate program admissions committees. Moreover, as in other career stages of the STEM pipeline where students from minoritized backgrounds leave academia, we have observed that as students start learning about the application process and what an “ideal candidate” looks like, those with perceived shortcomings are likely to self-select out of the applicant pool[8,9,12,35,36]. Therefore, encouragement and guidance are necessary to show them that these issues are addressable.

The CL-GSMI program provides applicants with mentors ready to discuss strategies, a community of applicants who are facing the same situations with whom to brainstorm, and a contact list of CL-GSMI volunteers who are available to reply through email.

For letters of recommendation, identifying the best-suited writers is not obvious

Graduate school applications require at least two letters of recommendation from a primary and secondary research mentor. A strong recommendation letter details the applicant’s research contributions, ability to succeed in graduate school, and capabilities as an independent researcher.

Letters of recommendation strongly influence the admissions process as a direct form of evaluation from a member of the scientific community that has personally interacted with the applicant[18,40,68–70]. Without proper guidance, applicants could reach out to a teaching assistant they have taken classes with or a favorite or admired professor who does not know them personally. Students from minoritized backgrounds, particularly first-generation college students, are especially impacted by this process, as they lack familiarity with the expectations that are required to navigate this application process for the first time[53]. CL-GSMI mentors are instructed to discuss with their applicant how to best use their experiences and network to select strong letter writers. This information is also covered in our webinars and guides.

Additionally, it is not uncommon for applicants to be asked by advisors to draft their own letters of recommendation[70–72], which often leads to applicants underselling themselves. One CL-GSMI applicant noted in their closing survey:

> "My mentor was AMAZING - she answered all of my questions, helped me with figuring out which schools to apply to, how to write my own letter of rec[comendation], and also just hyping me up when I was worried my resume wasn't good enough to apply to schools/fellowships."

We did not collect data on how many CL-GSMI participants had written at least one of their own letters of recommendation. However, it would be informative to have further data and research on this phenomenon.

As an applicant, it is difficult to know if and how to contact potential PhD advisors

In some fields, applicants are expected to directly contact and interview with a professor of interest before they apply to a graduate program. This expectation particularly relevant to students interested in graduate programs in computer science, ecology and evolutionary biology, and some psychology fields. If the applicant does not have access to a mentor that has been through that field's specific application process (for instance, if an applicant is switching research fields), it is difficult to know about this requirement. Additionally, applicants need to be aware of the particular etiquette for contacting professors and demonstrating interest, which is not generally known unless acquired from others or past experience. CL-GSMI mentors and guides can help applicants navigate how to contact the professors with whom they are interested in working.

Mentorship: Screening and Guidance for Mentors for Minoritized Students

Supportive mentors can provide a long-lasting impact on a student's academic career and play a vital role in helping students navigate graduate school applications. To be effective for minoritized students, mentors must be aware of obstacles their students face to help develop strategies to overcome them[55,57,73–76].

Examples of such situations include how to proceed if a research mentor is unwilling to write a recommendation letter or if the student is concerned about applying to programs with very few students from minoritized backgrounds. These sensitive scenarios require a sufficiently open-minded and empathetic mentor to listen to their mentee's concerns, provide support and encouragement, work with the student to address the problem at hand and adapt their mentorship style to the needs of their mentee. We developed a format to identify volunteers who would be supportive mentors to CL-GSMI applicants. These principles and training would benefit doctoral programs if implemented in the training of mentors of minoritized students, such as thesis advisors[75,77].

Sensitivity screening for mentors to minoritized students

CL-GSMI selected its mentors based on an evaluation of their ability to demonstrate good mentorship practice and their commitment to diversity and inclusion.

We ask every mentor to write short answers on 1) their approach to mentoring, 2) how they adapt their mentorship style to increase diversity and inclusion, and 3) what were their biggest concerns when they applied to graduate school. These questions allowed us to gauge their experience or predict their abilities in mentoring minoritized students. For instance, if they faced similar challenges during their graduate admissions process, it might allow them to provide practical advice, relate to or at least empathize with their mentee. For example, a response to the question about mentoring approaches that would disqualify a potential mentor would be

> "I have already mentored students before and understand the requirements."

This response does not provide insight into mentorship style, adaptability, or empathy. If prospective mentors demonstrate that they can reflect on their mentorship style and experience, and are supportive and patient, this predicts an ability to give sound, individualized and grounding advice. This approach to mentorship is beneficial for overwhelmed students who are usually juggling academic courses, work, and other obligations.

We also screen mentors for sensitivity to challenges that minoritized students might face, using real-life case studies of challenges previously faced by anonymous CL-GSMI applicants. Case studies require open-ended answers from prospective mentors on advising an applicant in each of the following situations: (1) poor GPA but strong research experience, (2) limited research opportunities, (3) struggles to meet expected deadlines with the mentor, (4) a first-generation college student concerned about the lack of diversity in graduate school, and (5) a research advisor who does not want to write the applicant a recommendation letter.

For example, the prompt for case number one is the following:

> Alberto is a first-generation college student and the first in his family to study science. He is majoring in physics at a state school. He has three years of research experience and has developed great skills in creatively solving scientific problems. He wants to apply to PhD programs, but he is concerned that there are not many scientists that look like him. He is worried science will not be a place he can thrive, and additionally worried that he might be one of very few students from an underrepresented background in some of the departments to which he is applying. How can you address Alberto's concerns?

An example of a response that would qualify the respondent as a CL-GSMI mentor to the previous prompt is:

> "I would both highlight Alberto's many strengths, while at the same time acknowledging his feelings, and validating them as legitimate. Then I would invite Alberto to search with me to find both organizations and active scientists that reflect his background and culture. We could extend into areas beyond physics. I would encourage Alberto to follow his passion, despite these challenges, if this PhD is truly what he loves."

This response demonstrates sympathy for the concerns of minoritized students in higher education and provides actionable steps to help Alberto build a community of scientists who have similar lived experiences. Ultimately, this assures us that this potential mentor will aspire to be supportive, validating, and adaptable to their mentee's concerns.

The prompt for case number two is the following:

> Cynthia is from a very small school in the U.S. and is a biochemistry major, but there are no research opportunities available in her school at all. She participated in a Research Experience for Undergraduates in summer 2019 and was accepted to another summer research program for 2020, but it was canceled due to COVID-19. Cynthia also got a summer research opportunity this summer 2021. She is certain that she wants to do a PhD but does not have extensive research experience with only two summer research experiences. What would you advise Cynthia to do?

An example of a disqualifying response to the second situation is:

> "They should apply for a research technician position after their summer research opportunity to strengthen their application."

This feedback discredits the applicant's unique situation attending a small institution that does not have research opportunities and does not acknowledge the applicant's efforts to seek out and participate in two summer research experiences. The student could incorporate these factors into a personal statement as strengths to highlight their passion for research, despite their limited opportunities. Furthermore, this response discourages rather than supports Cynthia's motivation to apply to graduate school. Many graduate school applicants apply to graduate programs more than once, so even if Cynthia does not have a successful application due to limited research experience, she can learn many lessons from the application process, such as identifying future career goals, time management, learning to craft her story, and effectively communicating research interests and results.

The prompt for case three is:

> Chris is an immunology major entering his senior year of college. He is thinking of applying to PhD programs, but has trouble meeting deadlines. Chris was supposed to give you a completed draft of his personal statement one week ago. You gave him another week and he still did not complete a draft. What should you do in this situation?

A disqualifying response to the third situation is:

> "If the applicant cannot meet deadlines, they should not be applying to graduate school."

In this case, the potential mentor is not considering external factors that might be affecting the applicant. Many applicants are completing their graduate school applications while juggling coursework, full-time jobs, and other obligations, such as familial caregiving[23], making it difficult to manage their time. An appropriate response would include reaching out to the mentee to gauge what factors are causing the delay, advising them to break up the

personal statement into smaller tasks that would be easier to achieve, or talking through time management strategies to handle their workload and various obligations.

Ultimately, disqualifying responses to these case studies reveal mentors who lack sensitivity to challenges minoritized students might face during the application process. In 2020, 97% of 679 evaluated mentor candidates passed the screening process. The process also exposed mentors to struggles that some CL-GSMI participants face and prompted critical thinking on how to best provide constructive advice to CL-GSMI applicants.

Additionally, mentors are provided with documents on good mentorship practices and a code of conduct to remind them of discriminatory practices they should avoid in their regular interactions with their mentees.

Mentors also benefit from direct support

It is critical to the success and community of CL-GSMI to support mentors throughout the program. Properly selecting, training, and supporting mentors is essential to ensure sustained long-term efforts at increasing representation in STEM[57]. We strive to improve this area of CL-GSMI each year and learn from ongoing efforts by others in the area of mentor education[75,77].

Beginning in 2021, we hosted a virtual mentorship training webinar and a private Slack channel where mentors could share or ask each other for advice on their experience. During this virtual training, we asked mentors to anonymously share what they considered a characteristic of a good mentor and what they were most nervous about in being a mentor themselves. Common traits identified in good mentors included being supportive, a good listener, encouraging, and constructive. Furthermore, many mentors were anxious about not having an answer to their mentees' questions. We were able to assuage mentors' concerns when going over mentor expectations and available resources.

We believe mentors should not be expected to know all the answers to every question but rather to know to whom they should turn for additional advice. If sensitive issues arise during the duration of the program that they feel unable to handle or effectively guide the student through, mentors can seek out support through the CL-GSMI Slack channel, team or program director.

Peer support and issues for which mentors sought support

Typical questions asked in the private mentor channel of the CL-GSMI Slack workspace relate to time management tips to help mentees juggle coursework and graduate school applications, crowd-sourcing fee waivers and funding opportunities for international students, and seeking connections among other mentors at specific institutions for their mentees. These interactions help create a sense of community between the mentors and an opportunity to network and peer-mentor with one another.

As with participants, after mentor-applicant matches are established, the CL-GSMI team keeps in regular contact via direct communication and indirectly through "Check-In Surveys" where either applicants or mentors can share general struggles and concerns.

These methods alert us to any issues involving the mentor or applicant where the CL-GSMI team could provide constructive intervention or re-pair the applicant with a new mentor if necessary.

When faced with more complex or sensitive issues, mentors tend to report in the monthly check-in survey or directly contact the CL-GSMI team. For instance, issues sometimes relate to the application process (e.g., how to advise a mentee on a fellowship the mentor did not apply for, what to do if the applicant becomes unsure of whether or not to apply), mental health-related issues (e.g., an applicant's family member having COVID, experiencing a personal tragedy), concerns for their mentee's ability to balance obligations alongside application to graduate programs. Examples of the latter included:

> "I think she's having a hard time starting the writing process. This could be due to academic load and personal situations. "

> "I think she is doing well but am worried about her having enough time to work on the apps outside of her full-time (80hrs/week) [*sic, 40hr/week?*] job in lab."

These statements demonstrate mentors reflecting on their mentee's limited ability to work on their application given other obligations. Mentors bring up instances such as these to the CL-GSMI team as potential roadblocks through which their mentees struggled to navigate. This is also an example of a mentor identifying an area where they need help supporting their mentee. Ultimately, problems such as these require individualized solutions, and assistance from the CL-GSMI team can help provide resources or additional perspectives, based on experience overseeing mentor-mentee pairs with similar issues. As highlighted by Mays and others, having mentors acknowledge and assist mentees' academic and non-academic challenges – especially those that are mental health-related – is critical to the collective efforts to foster STEM as a more inclusive space[76].

Mentor community and satisfaction

CL-GSMI mentors reported a program satisfaction (1=poor, 5=excellent) at 4.59 out of 5 in 2020 and 4.54 in 2021 (Table S3). Mentors reported on the time commitment of CL-GSMI by the frequency of meeting their mentee: at most 2–3 times a month (50.42% in 2020 and 49.21% in 2021) (Table S3). Representative statements from the CL-GSMI closing survey summarize mentors' experience volunteering:

> "I really enjoyed working with and learning from my mentee. I was inspired to learn more about his life and interests and appreciated the opportunity to try to contribute some of what I have learned from my own application process to PhD programs."

> "Getting to help a student who was in my shoes just a year ago and pass on knowledge that I wish I knew at the time. Helping a fellow Latinx student to navigate academia."

> "Very positive! There's so much about applying to grad school that can be helpful to students but many of them may never have access to those resources; thus, creating a space where students from more underprivileged and diverse backgrounds can seek help is a fantastic thing."

Mentors appeared satisfied with their experience in CL-GSMI. Between 2019 and 2021, 21% of CL-GSMI mentors volunteered for more than one year (108 out of 524 unique individuals).

Other features of CL-GSMI mentors

In both 2020 and 2021, the institutional representation of CL-GSMI mentors was diverse. The highest number of CL-GSMI mentors came from UC Berkeley, Harvard University, Duke University, and Yale University. However, a single institution never represented more than 8% of the CL-GSMI mentors (Table S4). The majority of CL-GSMI mentors preferred the pronouns “she/her” (67.24% in 2020 and 56.76% in 2021). The ethnicity of mentors was mainly white (52.07% in 2020; 52.90% in 2021) followed by Hispanic (34.83% in 2020; 33.98% in 2021) and Latine (including Latino/a/x) (32.76% in 2020; 29.73% in 2021). Additionally, nearly a third of mentors were first-generation college students (31.72% in 2020; 28.57% in 2021) or came from low-income backgrounds (30.34% in 2020 and 30.50% in 2021) (Table S1).

Financial Barriers Exacerbate Inequality

The financial burden of applying to graduate school is an enormous barrier to students from low-income backgrounds[26,28,48]. Application fees range from $50 to $135, and CL-GSMI applicants apply to 6.5 programs on average (Table 5). Graduate school applicants in general are predominantly undergraduate students, recent college graduates, postbaccalaureate students, and lab technicians with limited independent income. Without outside financial support, such as from family, it is challenging to support application costs. Additionally, graduate programs do not have a standard and accessible system for acquiring fee waivers; some require completing financial aid information, writing an essay to explain financial need, having a GPA above a cutoff. The time and effort involved in acquiring fee waivers deters low-income students, and therefore waiving application fees needs to be more easily accessible for an equitable admissions process[28]. This financial barrier prevents low-income students from accessing higher education in the sciences.

Acquisition of fee waivers for CL-GSMI applicants

Of all the facets of graduate school admissions that create inequity, the financial barrier is among the most easily addressed. Since 2019, we have kept a running list of programs and departments that do not require application fees, which we make publicly available in addition to providing it to CL-GSMI applicants. Additionally, in the past two years, CL-GSMI has partnered with over 25 universities or graduate programs to waive application fees for qualifying students in the CL-GSMI program. CL-GSMI applicants used 272 fee waivers in 2020 and 446 fee waivers in 2021 (Table 5). This centralized acquisition of fee waivers has relieved significant financial burden for CL-GSMI applicants.

We surveyed the CL-GSMI participants on how the availability of fee waivers impacted the number of programs to which they applied. Participants reported a positive impact with an average ranking of 3.7 out of 5 in 2020 and 3.9 out of 5 in 2021, indicating that the availability of fee waivers played a role in their decision to apply to those programs (Table

5). Because of fee waivers, CL-GSMI applicants could apply to and consider additional graduate programs to which they may not have previously had the resources to apply.

Discussion: Suggested Approach for the Future

Increasing the number of minoritized students in STEM higher education requires a collective and sustained effort across academic culture and institutions, with progressive solutions agreed upon by diversity and inclusion leaders, administrators, and scientists[78]. With CL-GSMI, we have focused on helping graduate school applicants realize their potential at a pivotal moment of transition in their careers as STEM professionals by providing them with information, mentorship, and lowering their financial burdens. We have helped 443 graduate school applicants matriculate to STEM graduate programs by providing access to a personal mentor, a professional network, webinars, mock interviews, and comprehensive written materials on the application process. Access to resources and mentorship at this critical stage of historically marginalized scientists' careers can improve innovation in the sciences for decades to come[79,80].

At the outset of crafting their graduate school applications, students from low-income and first-generation backgrounds may lack the information required to succeed in graduate school applications or the networks needed to obtain it. Although scientific talent has no relationship to socioeconomic or cultural background, the social expectations, cultural norms, and etiquette of navigating higher education is an acquired skill that requires guidance. Prospective applicants will only receive interviews or admission offers with a deft understanding of how to present themselves to admission committees.

The "hidden curriculum" (social and cultural capital) in academia

In educational research, the "hidden curriculum" refers to the implicit socialization one is taught throughout their education. It is not delineated in a curriculum, and refers to values, behavioral norms, and expectations or obligations[55,81]. Due to the different parental backgrounds and upbringing of children, this learning of educational norms can start when a student first attends school. Furthermore, this cultural socialization continues along the STEM career trajectory. For instance, international students who come to the U.S. for their bachelor's degrees acutely feel the hidden curriculum. If a student is educated in a distinct educational or cultural background, they may have no way of knowing the meaning of the phrase "office hours", or other basic features students are assumed to be familiar with and that are needed to successfully navigate the U.S. academic environment[82].

The hidden curriculum of higher education in the U.S. includes social and cultural expectations that align with those of the white middle class[55,83]. Students who are born into or spend considerable time in environments with similar norms and expectations will have an advantage through accrued social and cultural capital. This capital demonstrates how "one's culture can act as [currency] in social settings where one can exchange cultural knowledge, skills, abilities, norms, preferences, or mannerisms for social rewards such as acceptance, recognition, inclusion, or even social mobility"[84,85].

Scientists who are from families with higher education, have family members in academia[24,25], or have access to a network of academic professionals due to generational wealth[52] possess these advantages over their peers when applying to graduate school[58]. For instance, students from lower socioeconomic status have been reported to be less integrated into academic communities[59], and first-generation students may have different expectations of their advisors compared to their peers[22]. As a result of this disparity in certain forms of cultural wealth, recent work shows that tenure-track faculty come from higher-income families than the U.S. population on average and are 25 times more likely to have a parent with a PhD (and this rate is higher at prestigious universities)[86]. In graduate school admissions, faculty and administrators assess applications for graduate school "readiness", which is subject to primarily unconscious "cultural favoritism" that leads to an advantage for students from this dominant group[16,17,38,55].

Importantly, there is a growing body of research expanding the framework of cultural capital in the context of higher education, suggesting that students from minoritized backgrounds also possess forms of social and community cultural wealth, such as peer support, that can be utilized to overcome barriers in academia[85,87,88,94]. Academia should better understand, support and enhance the existing cultural capital that students from minoritized backgrounds bring to make STEM higher education more legitimately and meaningfully inclusive rather than perpetuating a "dependency on demystifying the hidden curriculum"[76,88].

Application Assistance Programs (AAPs) can address inequity in the graduate school admissions process

In the short term, to make the graduate school application process more accessible, academic institutions can implement AAPs, host workshops on the graduate school application process to prospective applicants, clearly outline the class size of domestic and international students per year, and publicly state whether they accept undocumented students in their program (see Figure 4 for an outline of suggestions). If needed, institutions can work individually or collectively on contracting academic consultants to help offset the individual labor of some of these initiatives, which is preferred over relying on unpaid student labor, particularly of minoritized graduate students[89].

There are several benefits for institutions to host AAPs, such as 1) playing a national role in creating an equitable application process and contributing to resolving underrepresentation in higher education in the sciences, 2) providing institutional scientists an opportunity to mentor minoritized students, 3) familiarizing themselves with the challenges minoritized students face, 4) improving the number of minoritized applicants to their university, and 5) ensuring that application expectations are communicated clearly to these applicants.

We have also seen a few universities and departments adopt similar, smaller-scaled models, such as MIT's Graduate Application Assistance Program (GAAP) and Johns Hopkins University's Biomedical Engineering Application Assistance Program (BMEAAP). Like CL-GSMI, other institutionally independent and student-run programs include MUSE mentorship and Project SHORT. We believe AAPs, like research experience for undergraduate (REU) programs, should be institutionally and federally funded as a direct

and effective intervention for making higher education more accessible to minoritized students from disadvantaged backgrounds.

Work by other organizations related to graduate school admissions

Other programs that provide application assistance as part of their mission include PREP, MARC, NIH Building Infrastructure Leading to Diversity (Build) Initiative, University of California Leadership Excellence through Advanced Degrees (UC Leads), LSAMP, NSF California Louis Stokes Alliance for Minority Participation (CAMP), NIH Blueprint Enhancing Neuroscience Diversity through Undergraduate Research Education Experiences (ENDURE), RISE, NIH Advancing Diversity in Aging Research through Undergraduate Education (ADAR), Collegiate Science and Technology Entry Program (CSTEP), Mellon Mays, and Biology Undergraduate Scholars Program (BUSP). Generally, these programs enable students to pursue a research experience for about 75% of their time and professional development, mentorship, academic support, and other resources specific to student needs for the remaining 25% of their time. These programs are essential. Research experience is critical for students' scientific careers and requires intervention before the graduate school application process begins[16,46,66]. We recognize and appreciate these programs' contributions towards increasing diversity and equity in higher education.

Although the programs above may provide students with a research mentor, engaged support on graduate school applications is outside the required responsibilities of research mentors and lab peers. Research mentors may not always have the bandwidth for application revisions, and the nature of their relationship with their mentee may factor into the extent of their support[20–22]. These students would benefit from CL-GSMI and other AAPs, which pair students with dedicated mentors for one-on-one support during the writing and interview process. We have observed that CL-GSMI and other AAP programs do not provide redundant support but are complementary in their efforts to support and uplift students from minoritized backgrounds. Mondisa and others have described how having mentors across multiple organizations and institutions ("microsystems") can lead to potential synergies and more well-rounded mentorship and can also be crucial to student success[57].

CL-GSMI is unique from other programs in its size and the eligibility requirements of participants. In each year of CL-GSMI's operation, we have assisted over 100 students across STEM disciplines in an accessible virtual format without requiring institutional affiliation. This may not be possible for other AAPs that may only have limited (sometimes less than ten) open slots per year. For example, since PREP programs began in 2001 with 41 participating institutions, most students they served were from institutions with substantial underrepresented minorities. 22% of participating students were from Hispanic Serving Institutions (HSI), 16% from Historically Black Colleges and Universities (HBCU), and 9% from Asian American Native American Pacific Islander Serving Institutions (AANAPISI)[90]. PREP programs reported that 64% of their students successfully matriculated into a PhD program after PREP completion[90]. Students who complete their bachelor's degrees at an institution not partnered with PREP or a similar program will not be able to access these resources.

Application fees must be eliminated for an equitable admissions process

Application fees perpetuate inequity in higher education and academia by specifically restricting the number of applications from less privileged students[28,91]. While universities and graduate programs may have administrative and practical considerations in mind when setting these application fees, they vastly underestimate the effect they have on entrenching inequity in graduate school admissions.

A common argument used to justify application fees is that they limit the number of "unserious" applications. There is a fear that without fees, applicants will "spam" programs with applications, even if they have not seriously considered that particular program/university. However, the effort and time required to complete an application is significant. We did not see any evidence to substantiate this fear in CL-GSMI cohorts. Although CL-GSMI participants had access to all the fee waivers from CL-GSMI partner universities (20 fee waivers in 2020; 32 in 2021), students put significant effort and carefully selected to which graduate programs they applied (Table 5). For students from wealthy backgrounds, application fees are not a significant barrier. *The application fee only limits the number of applications from students of low-income backgrounds*.

While some graduate programs have various paths for requesting fee waivers, these often require funding to attend specific conferences (e.g., Society for Advancement of Chicanos/Hispanics & Native Americans in Science (SACNAS), Annual Biomedical Research Conference for Minoritized Scientists (ABRCMS), access to programs that may not be available at their university (e.g., MARC, McNair Scholars Program), or a varying amount of bureaucratic and writing effort. This demands additional time from applicants on top of the already considerable graduate school application components they face. Furthermore, some of these fee waivers are only eligible for students with a GPA above a cutoff. They are also often limited to U.S. citizens or permanent residents, completely excluding international or undocumented students, effectively limiting applications from less privileged applicants.

In recent years, several doctoral programs have eliminated application fees, including Rice University's Systems, Synthetic, and Physical Biology PhD program, Scripps Research Institute's Doctoral Program in Chemical and Biological Sciences, and Dartmouth University's Graduate Program in Chemistry. In considering the elimination of application fees, graduate programs should investigate how these programs can sustain their free application model. It will be enlightening to learn from these graduate programs what the impact of no application fee is: Will the application pool truly become impossible to wrangle, or will this decision lead to a more diverse and successful graduate student cohort?

For international and undocumented students, the financial burden of application fees compounds the additional barriers they face

A distinct feature of CL-GSMI is our ability to support international students and undocumented immigrants, who are often ineligible for other AAPs due to residency restrictions. Undocumented and international students face many additional challenges in navigating the graduate school application landscape.

Undocumented students must go through additional hurdles in academic bureaucracy to determine which schools can even accept them due to their immigration status[92], let alone provide funding throughout their time in the graduate program. These policies are frequently unclear even to a graduate program's administration and faculty.

Undocumented and international students are rarely eligible for fee waivers, paying the same application costs as other students for a much slimmer chance of acceptance. Depending on the economic situation in their country of residence, the relative cost of graduate school applications for an international applicant can be astronomical (as much as one month's salary to submit one application). Due to limitations on federal funding for graduate program student stipends, international students often have fewer spots available to them thus making it more difficult for them to be accepted compared to domestic students (Table 2). Because information is scarce on how many graduate school spots are available for international students or what percentage of past cohorts were international, it is challenging for undocumented and international students to strategically allocate their limited monetary resources to institutions more willing and able to consider their admission.

In cases where a domestic CL-GSMI mentor was paired with an international or undocumented applicant, they frequently mentioned concerns about their ability to help. For example,

> "I don't have experience with coming to the US or Canada from another country for graduate school (so English as a second language tests, immigration concerns, etc.)"

> "It was great; I really enjoyed working with my mentee, getting to know her, and helping her. The saddest realization for me while being a part of this program is how few funding opportunities are available to international students that are not US citizens."

> "My mentee needs to take the TOEFL. That test is very expensive. I would like to point to some waivers or something like this. She also needs to translate her transcript to English since her university is in a Spanish speaking country and that ALSO costs money."

Dedicated CL-GSMI mentors frequently sought funding or immigration-related information on behalf of their mentees despite numerous challenges. However, even these individuals often found it impossible to bypass these barriers to obtain the necessary information or identify the correct opportunity to help their mentee. It is noteworthy that these mentors, despite their proven qualifications in a STEM graduate program, and their ability to utilize their own social and cultural resources, still struggled to help undocumented or international applicants overcome the same hurdles that the applicants would have been expected to surmount on their own.

CL-GSMI activated an increase in diversity and inclusion awareness and action

CL-GSMI has led to growth in diversity and inclusion awareness and independent efforts. Comments from mentors that illustrate this include,

> "I appreciated better understanding some of the structural barriers towards achieving equity in graduate school"
>
> "My experience was great and I'm excited to hopefully be a mentor again in future years."
>
> "I think you're doing great already! You actually inspired me and a friend to start an application assistance program for our specific graduate program. Keep up the great work!"

Overall, CL-GSMI mentors are committed to diversity and inclusion, and CL-GSMI offers them an opportunity to connect and learn from their mentees (or soon-to-be colleagues) with different backgrounds across state and national borders. 21% of CL-GSMI mentors volunteered more than once (108 out of 524 unique individuals). Although the CL-GSMI matching process de-prioritizes first-year graduate students as prospective CL-GSMI mentors (they often have classwork loads and are just gaining footing in their new environments), 30 CL-GSMI applicants also returned in following years to mentor new CL-GSMI cohorts or volunteer to be on the CL-GSMI team. We have also observed other CL-GSMI applicants and mentors subsequently participate as mentors in graduate school application assistance programs at their respective universities, or have founded their own diversity and inclusion or outreach initiatives. We are excited about the growing community of support and potential for future graduate school applicants from historically minoritized backgrounds.

Ongoing improvements to CL-GSMI and program feedback from CL-GSMI mentors

One of the areas of CL-GSMI that we are most actively developing is mentor education and training. In the future, we plan to include more mentor training by inviting professional speakers to host diversity and equity training sessions, provide suggested reading materials and resources on mentoring minoritized students, and host small group discussions to reflect on and discuss mentoring practices and how to support minoritized students.

We strive for adaptability and seek to improve CL-GSMI every year by taking into account CL-GSMI applicant and mentor concerns. In program surveys, four common suggestions for improvements brought up by mentors were (1) providing more detailed timelines and suggested deadlines for application deliverables, such as personal statements, (2) adding additional resources on the CL-GSMI website, (3) hosting university-specific webinars for applicants to learn more about institutions they are interested in applying to, and (4) creating more opportunities for mentors to engage with each other.

Mentors, as well as graduate school applicants, provide a crucial source of feedback for improving CL-GSMI. For instance, we plan on developing a more granular checklist and timeline that mentors and applicants can use to help structure their mentorship relationship, improve mentors' ability to track their mentees' progress, and help mentees effectively manage their time as they complete their graduate school applications.

CL-GSMI is unique in being trainee-run, having less restricted participant eligibility, support of mentors, and other features

CL-GSMI is unique as a grassroots organization run by graduate students and postdoctoral scientists independent of institutional affiliation that provides students from minoritized backgrounds tools to support them through their graduate school applications, including one-on-one mentorship, online resources, educational webinars, professional network, mock graduate school interviews, and fee waivers (Figure 1).

CL-GSMI participants achieved an 81% acceptance rate for 207 out of 253 students that applied in 2020 and a 71% acceptance rate for 160 students out of 225 that applied in 2021. Additionally, we had 21 participants receive the competitive NSF-GRFP (Table 6). CL-GSMI is not solely responsible for the achievements of its participants, as each individual comes with a unique background, network, experiences, privileges, and disadvantages in the graduate school application process. Nonetheless, we are encouraged that both CL-GSMI applicants and mentors reported a high and surprisingly stable level of program satisfaction over 2020 and 2021, indicating that their experience in CL-GSMI was likely helpful, meaningful, or otherwise worthwhile (Tables 4 and S3).

CL-GSMI depends on and is only possible because of the mentors, whom we selected through a screening for their responsiveness to the unique obstacles that minoritized students face and their commitment to understanding and addressing structural barriers to achieving equity in graduate education. We had mentors across several institutions (Table S4) whom we encouraged to be vulnerable and honest with their mentees by sharing their experiences applying to graduate school. Consequently, they provided a safe space for CL-GSMI mentees to grow and become their best selves while learning how to navigate the often confusing and convoluted process of applying to graduate school. Furthermore, some mentors continue to their mentees even after the program has concluded.

By providing a space for students, postdoctoral scientists, and faculty to become directly involved in minoritized students' experiences applying to graduate school, the impact of CL-GSMI goes beyond assistance with graduate program applications. As present and developing future scientists gaining hands-on experience in mentoring others, this is a process that could benefit the whole scientific enterprise.

Finally, one of the critical benefits of CL-GSMI is the sense of community and belonging we provide for students from minoritized backgrounds across STEM disciplines, institutions, and national and international borders. We strive for inclusivity in supporting a large pool of students from different historically minoritized backgrounds and without immigration status restrictions, whenever possible, considering students' unique obstacles. This community and diversity of perspectives provides a sense of solidarity among students pursuing the arduous and isolating process of applying to graduate school.

These features have allowed us to strengthen our CL-GSMI program to run an effective model to help minoritized students with their STEM graduate school applications. CL-GSMI directly supports the STEM professional pipeline by providing students with tangible disadvantages and a fair shot at pursuing graduate education. By providing more details

of our model, institutions can provide informed support to minoritized students pursuing higher education in STEM. Despite the challenges we face, programs such as CL-GSMI help move us towards the critical goal of making underrepresentation in STEM a relic of the past.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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In this Perspective, members of the Científico Latino Graduate Student Mentorship Initiative (CL-GSMI) review factors contributing to an inequitable STEM higher education admission process. They provide data and detail about their program's strategies to support students from minoritized backgrounds and help counteract the disadvantages they face during graduate school admissions.

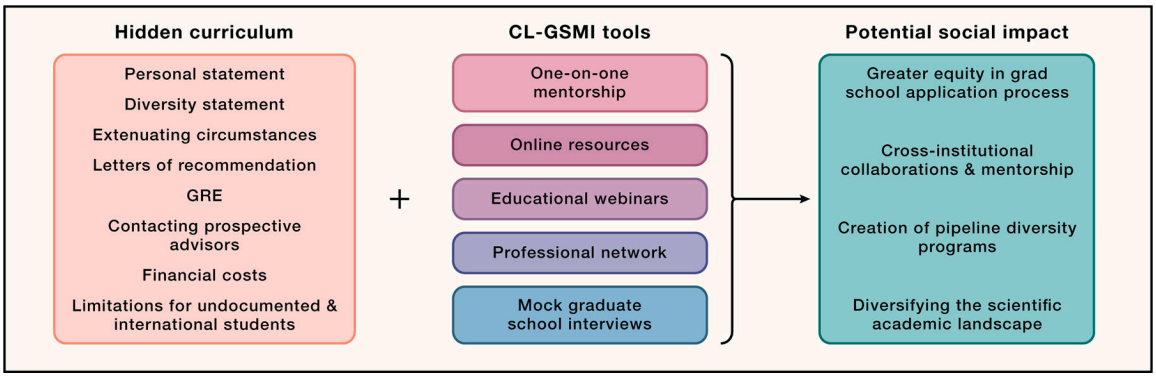

Figure 1. The impact of the CL-GSMI program.

An illustration showing features of the hidden curriculum of graduate school application in the sciences, the tools that the Científico Latino GSMI program uses to intervene to promote equity in graduate school admissions, and possible long-term impact of their mentorship program.

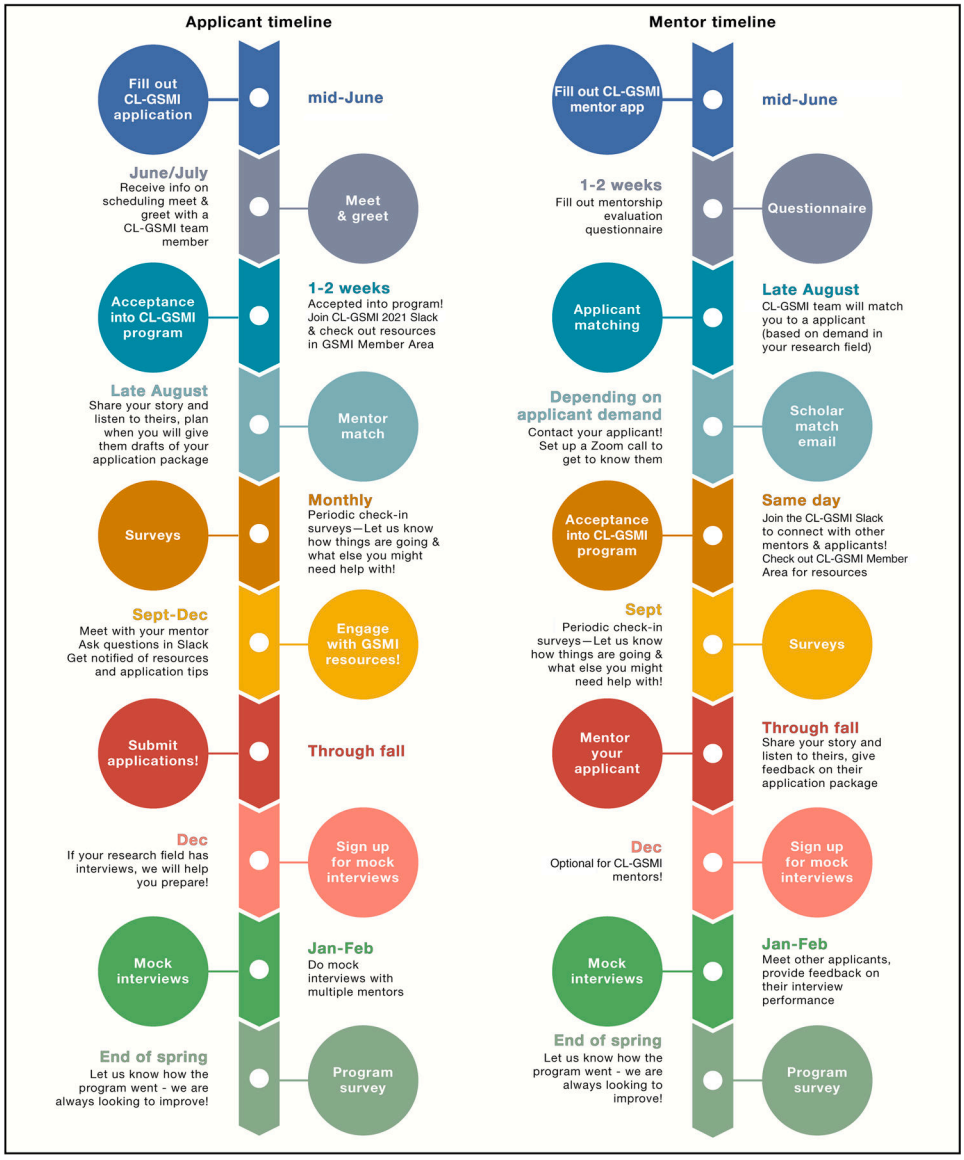

Figure 2. CL-GSMI program timelines.

An illustration showing the GSMI application timeline for participating in the CL-GSMI program as (**A**) an applicant or (**B**) a mentor.

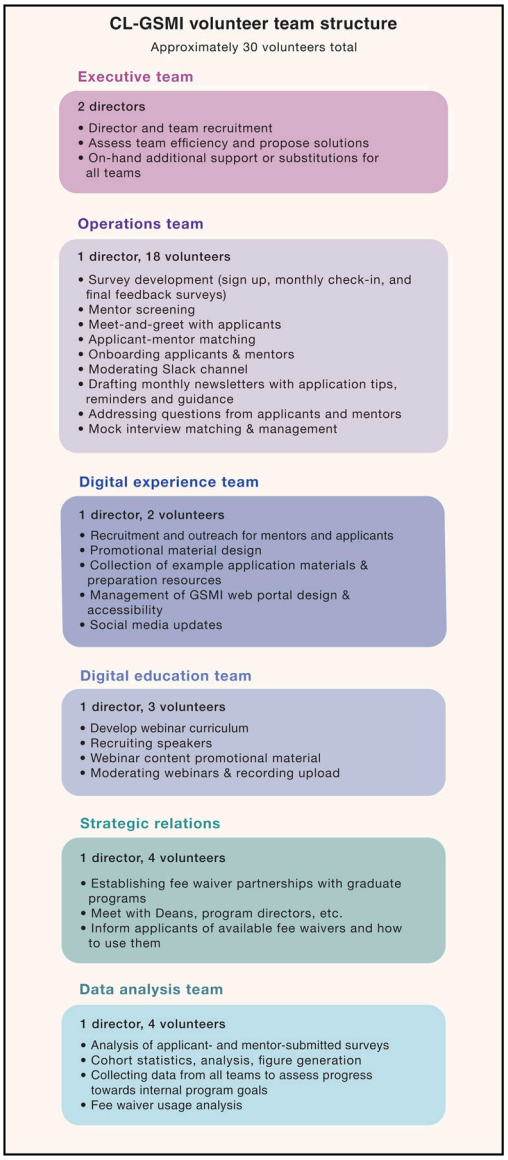

Figure 3. CL-GSMI team structure.

An Illustration of CL-GSMI team structure and delegation of responsibilities between approximately 30 volunteers.

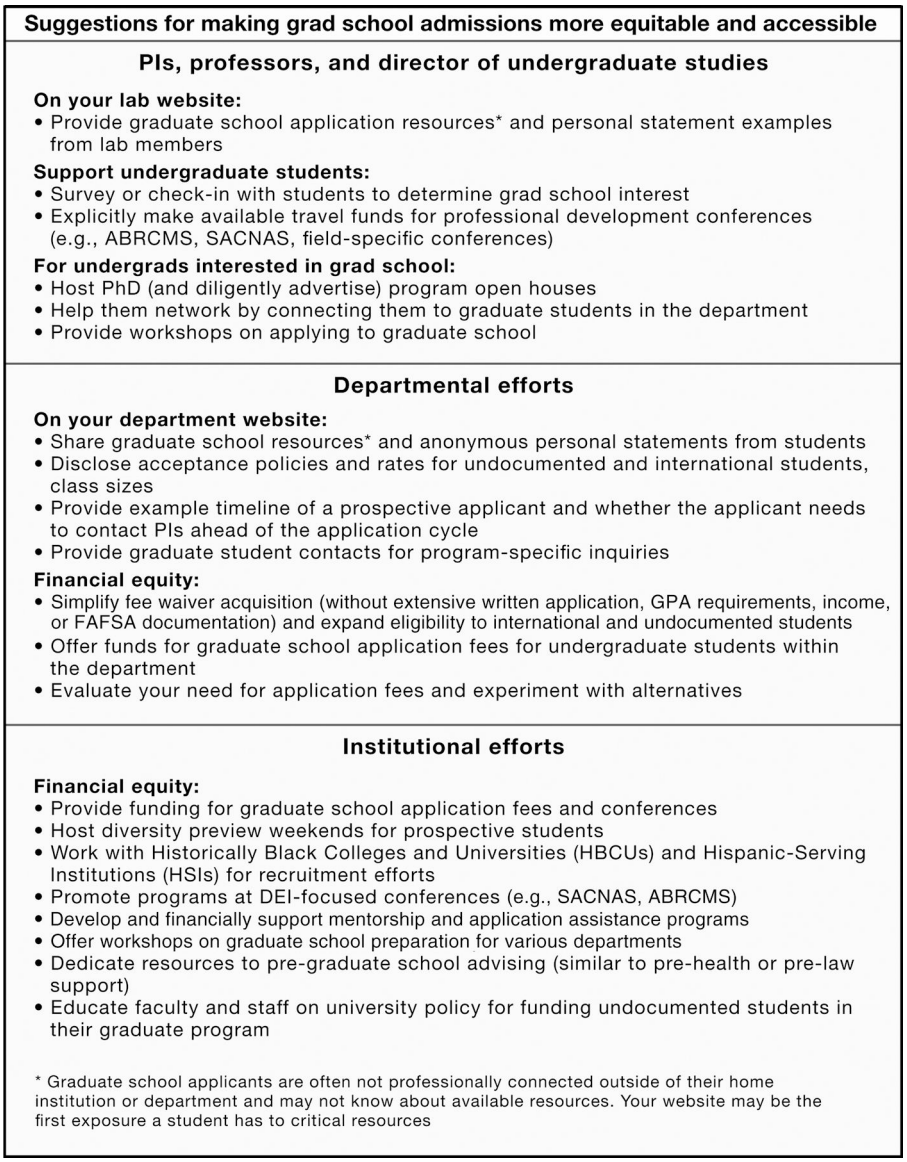

Figure 4. Actionable items for multi-level increasing of graduate school admissions equity and accessibility.

Actionable items that individuals in the sciences (PIs, professors, Director of Undergraduate Studies), departmental efforts, and institutional efforts that can be enacted to improve equity in graduate school admissions.

Table 1.

CL-GSMI participants involvement in other science outreach and preparatory programs.

Program participation is non-exclusive, some participants may have participated in more than one.

	CL-GSMI 2020 (290 responses)	CL-GSMI 2021 (259 responses)
Postbaccalaureate research programs *	30 (10.34%)	9 (3.47%)
Other programs	50 (17.24%)	14 (5.41%)
LSAMP (Louis Stokes Alliances for Minority Participation)	18 (6.21%)	5 (1.93%)
MARC (Maximizing Access to Research Careers)	12 (4.14%)	0
RISE (Research Training Initiative for Student Enhancement)	9 (3.10%)	2 (0.69%)
BUILD	5 (1.72%)	2 (0.69%)
NSF CAMP (California Alliance Minority Participation)	2 (0.69%)	1 (0.34%)
ENDURE (Enhancing Neuroscience Diversity through Undergraduate Research Education Experiences)	2 (0.69%)	1 (0.34%)
UC LEADS	1 (0.34%)	0
ADAR (Advancing Diversity in Aging Research)	1 (0.34%)	0
CSTEP (Collegiate Science and Technology Entry Program	0	1 (0.34%)
Mellon Mays Undergraduate Fellowship Program (MMUF)	0	1 (0.34%)
BUSP (Biology Undergraduate Scholars Program	0	1 (0.34%)

* Includes McNair Scholars Program, Bridge to PhD, and PREP (Postbaccalaureate Research Education Program)

Table 2.

Acceptance information for CL-GSMI 2020 and 2021 applicants.

Self-reported counts collected from a survey sent at the end of the graduate school application cycle. Total responses are noted in column headers, as not all CL-GSMI applicants complete each survey. In our 2019 pilot year, there were a total of 76 students that were accepted to graduate school programs (data not shown). Including 2019, 443 total CL-GSMI applicants were accepted to graduate school programs.

	CL-GSMI 2020 (274 responses)	CL-GSMI 2021 (241 responses)
Students that applied	253	225
Students that did not applied	21	16
Students that were accepted (acceptance rates in parentheses)	207 (81.82%)	160 (71.11%)
Domestic students	154 (83.70%)	78 (82.98%)
International students	53 (76.81%)	82 (62.60%)
Master's programs	30	29
Doctoral programs	177	131

Table 3.
Demographics of participants (CL-GSMI 2020, 2021).

Self-reported counts from a survey sent at the end of the graduate school application cycle. We acknowledge the limitations of categorical labels of ethnicity and race, which oversimplifies complex and nuanced identities of individuals. Applicants are permitted to select multiple responses per question, if applicable, and fill in additional information if they wished (but this could not be aggregated). Total responses are noted in column headers, as not all CL-GSMI applicants complete each survey.

Demographic Characteristics	CL-GSMI 2020 (290 responses)	CL-GSMI 2021 (259 responses)
Gender Identity		
Woman	196 (67.6%)	154 (59.46%)
Man	78 (26.9%)	89 (34.36%)
Nonbinary	11 (3.8%)	3 (1.16%)
Queer	1 (0.34%)	1 (0.39%)
Ethnicity		
Hispanic	130 (44.8%)	73 (28.19%)
Latinx	153 (52.8%)	94 (36.29%)
Black	46 (15.9%)	68 (26.25%)
Middle Eastern	9 (3.10%)	3 (1.16%)
East Asian	23 (7.93%)	25 (9.65%)
South Asian	22 (7.59%)	47 (18.15%)
Pacific Islander	3 (1.03%)	0 (0.00%)
Indigenous	11 (3.79%)	8 (3.09%)
White	33 (11.38%)	25 (9.65%)
Multiracial	22 (7.59%)	19 (7.34%)
Applicant Status		
U.S. Citizen/Permanent Resident	205 (70.69%)	90 (34.75%)
International	71 (24.48%)	139 (53.67%)
DACA/Undocumented/Other	10 (3.45%)	16 (6.18%)
Additional Identifying Factors		
First-Time Applying to Graduate School	208 (71.72%)	164 (63.32%)
First-Generation College Student	141 (48.62%)	103 (39.77%)
Low-Income	187 (64.48%)	173 (66.80%)
Attended Community College	48 (16.55%)	69 (26.64%)

Table 4.

CL-GSMI program satisfaction.

Self-reported counts from a survey sent at the end of the graduate school application cycle addressing applicant satisfaction with the CL-GSMI program and mentorship. Total responses are noted in column headers, as not all CL-GSMI applicants complete each survey.

Survey Question ***Scale from 1–5 (1=poor, 5=excellent) ± s.d.***	**CL-GSMI 2020 (290 responses)**	**CL-GSMI 2021 (259 responses)**
How happy are you overall with the Cientifico Latino GSMI program?	4.81 (±0.44)	4.79 (±0.46)
How happy were you with your paired mentor?	4.61(±0.80)	4.73 (±0.68)
Did you get in touch with your mentor as much as you liked?	4.42 (±1.127)	4.56 (±0.96)
In terms of your individual situation or background while applying to graduate school, was your mentor supportive/understanding?	4.77(±0.57)	4.79 (±0.55)

Table 5.

Impact of CL-GSMI fee waivers.

Self-reported numbers from a survey sent at the end of the graduate school application cycle. Standard deviation is indicated in parentheses. Total responses are noted in column headers, as not all CL-GSMI applicants complete each survey.

	CL-GSMI 2020 (290 responses)	CL-GSMI 2021 (259 responses)
Did the availability of fee waivers have an impact on the number of schools you applied to? *Scale from 1–5 (1=poor, 5=excellent) ± s.d.*	3.70 (±1.55)	3.92 (±1.45)
Average institutions applied to per applicant	6.51(±4.40)	6.73 (±3.79)
Number of program fee waivers made available by CL-GSMI	20	32
Total fee waivers used	272	446
Total students that used fee waivers	111	152
If used fee waivers, average fee waivers used	2.43 (±1.76)	2.93 (±2.06)

Table 6.

Fellowships.

Students that were awarded fellowships during the application cycle in which they participated in CL-GSMI.

	CL-GSMI 2020 (290 responses)	CL-GSMI 2021 (259 responses)
GEM	11 (3.79%)	3 (1.16%)
NSF-GRFP	15 (5.17%)	6 (2.31%)
NSF-GRFP (Honorable Mention)	1 (0.34%)	0
Other external/internal fellowships	24 (8.27%)	20 (7.72%)