OPINION

Considerations for Increasing Participation of Minoritized Ethnic and Racial Groups in Mathematics

James A. Mendoza Álvarez and Minerva Cordero

Note: The opinions expressed here are not necessarily those of Notices.

When addressing a group of students and faculty, a colleague says, "There are opportunities for summer mathematics programs; *unfortunately*, these are only for minority students." During a discussion about ways to increase access for minoritized[1] groups, a colleague offers, "Oh, but *you're* different," effectively disregarding suggestions made by a faculty member from a minoritized ethnic group. When discussing the academic job market and negotiations, a colleague remarks, "Well, you're the good kind of Hispanic because you don't *look* Hispanic." Surprisingly, this is a sampling of comments made in professional settings in mathematics that can discourage mathematicians of color or relegate them to an inferior status that neither recognizes their contributions as professionals nor values their unique perspectives in addressing issues of disenfranchisement of students of color in mathematics. Regrettably, microaggressions such as these, experienced by mathematics faculty from minoritized ethnic and racial groups, are far too common. Why is it *unfortunate* that only minority students can apply for certain mathematics programs when their access and participation has been historically abysmal in many mathematics programs? Judgments and stereotypes about how one should look or act when one identifies with an ethnic group compartmentalize members of minoritized groups and do not recognize the wide diversity in ethnic communities. What are the differences between students or colleagues from ethnic or racial groups historically marginalized in mathematics and those who have not been?

In this article, we share our perspective on increasing participation of minoritized ethnic and racial groups in mathematics, informed by our experiences as Hispanic mathematicians[2] who have successfully navigated the world of academia. James grew up in rural south Texas and attended East Texas State University;[3] he received his PhD in percolation theory from the University of Texas at Austin. During his final years at Austin he became interested in

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[1] *We choose the term minoritized instead of minority to connote the marginalization imposed by individuals or institutions on people of color.*

Communicated by Notices *Associate Editor William McCallum.*

DOI: https://dx.doi.org/10.1090/noti2223

[2] *For full transparency, the authors are also husband and wife.*

[3] *East Texas State University became Texas A&M Commerce in 1996.*

research in mathematics education. Minerva grew up in the countryside in Bayamón, Puerto Rico, and attended the University of Puerto Rico. She received her PhD in finite geometries at the University of Iowa. To situate and reflect on our experiences in mathematics as students, teachers, and researchers, we use Gutiérrez's [Gut07, Gut08] framework to conceptualize equity in mathematics education and Ladson-Billings's [Lad95] propositions that distinguish culturally relevant pedagogy.

Gutiérrez [Gut07] describes four dimensions of equity in mathematics education: access, achievement, identity, and power. To achieve equity, students need access to meaningful mathematics and mathematics resources; in turn, this access must translate into *achievement* outcomes that enable advancement. Moreover, Gutiérrez [Gut08] points out that many studies about differences in performance between minoritized ethnic and racial groups in mathematics and nonminoritized groups focus solely on access or achievement with little attention given to the dimensions of *power* and *identity*. Hence, focusing on power imbalances between minoritized and nonminoritized communities may provide insight into complex issues affecting efforts to increase the number of students from historically marginalized ethnic or racial groups in science, technology, engineering, and mathematics (STEM). Additionally, we must consider the effects of minoritized individuals' perceived pressure to minimize familial or cultural ties to pursue their career choices or adapt to the profession. Gutiérrez emphasizes that studies that narrowly focus on issues of access and achievement have limited ability to address issues of power and identity.

We begin exploring the equity dimension of achievement. Our personal *achievement* in mathematics in our early years perhaps is not so different from our nonminoritized peers. We would both be described by our former teachers as high achievers, having each graduated at the top of our high school classes. The rural schools in south-central Texas and Puerto Rico we attended certainly do not rise to the level of the best schools by almost all metrics, but our experiences and self-perception as academically capable, especially in mathematics, shaped our ideas about persistence and achievement. National Medal of Science awardee Professor Richard Tapia often states that he did not go to a top-notch high school or community college, but in each of those environments he was "the best," and encourages students to strive to "be the best" in whatever environment in which they find themselves [NSTMF19]. In Treisman's [Tre92] research, which led to the creation of the widely successful Emerging Scholars Programs (Treisman-style), he specifically addresses capitalizing on STEM-intending minoritized students' perception of themselves as academically capable (see also [HMT07, Epp99]). Asera [Ase01] describes this as Treisman-style programs' emphasis on "knowing who your students are and recognizing their strengths" [Ase01, p. 11]. Recognizing the significant achievement in mathematics of minoritized students, given their limited exposure to common experiences afforded to students in high-profile schools or from affluent backgrounds, provides a foundation for valuing the contributions of students from underserved communities. This recognition also presents opportunities for finding ways to provide experiences that validate their past achievement in mathematics and for helping them build appropriate pathways that prepare them for a successful career as a mathematician.

A focus on validating past achievement in mathematics, while creating bridges to critical mathematical thinking that positions students for further study of mathematics, underscores the need for access to teachers, programs, and other experiences that build upon students' ways of knowing. That is, their culture, current family life, neighborhood, and school environment affect their perspectives in ways that many teachers, who do not come from similar backgrounds, may not understand [Civ17]. Thus, the first step toward increasing access should be understanding the human beings involved and their environment; when omitted, well-intentioned efforts promoting "the right mathematics program" for underserved schools often backfire. Putting rich mathematical problems within a student's grasp entails providing scaffolding and other strategies for helping the student see the relevance of the mathematics involved. Some ways of doing this are to provide a historical, cultural, or social context; to situate the knowledge in future career plans; or to be more explicit about how mathematical ideas build from foundational knowledge. From 2009–2015 we had funding from the National Science Foundation Graduate Teaching Fellows in K–12 Education (GK–12) Fellowship Program (NSF DGE #0841400) to work with students and teachers from middle and high schools. We selected schools with the highest percentage of students from historically marginalized ethnic or racial groups in STEM and where the majority were socio-economically disadvantaged (over 90% of the students were from these populations). The goal of the *Mathematically Aligned Vertical Strands Connecting Mathematics Research Pedagogy, and Outreach for GK–12 Fellows and Teachers* (MAVS) project was to develop mathematicians who could communicate research in mathematics in a meaningful way to a broad audience. The underlying principle of the program encompassed building an understanding of the students, teachers, and school environment to better situate a partnership between teachers, research mathematicians, and graduate students [see CEJ14]. The graduate students partnered with teachers to explore the mathematics curriculum in their courses and how they could build a roadmap between their research in mathematics and the mathematics students were learning. The graduate students spent at least ten hours per week in the classroom with the teacher getting to know the school environment and the students. We held steadfast to the idea that we would work

with the highest need schools. Moreover, we insisted that professional development for the graduate students and teachers emphasize high-quality mathematics that started from where the students were. Our commitment to this, even when facing challenges, remained unwavering, in part because of our own personal and professional understanding of underserved environments. The program integrated our firm belief that students be provided experiences that help them make connections between the mathematics they are learning, the mathematics they will learn, and the ways in which it is relevant to their lives. For example, in a seventh-grade class when students were working with unit rates, the graduate student connected this to building insight into the fact that rates are not always constant and into how understanding cell population growth rates was important to her research modeling the inflammatory response during the healing process such as after eye surgery or receiving dental implants.

Achievement and access, as Gutiérrez [Gut08] points out, are often the focus of discourse for addressing issues related to increasing the pipeline of minoritized communities in mathematics and mathematics-based disciplines, but the other two dimensions of equity, those of identity and power, receive less attention. What exactly does identity mean for two Hispanic (one Chicano and one Puerto Rican) full professors in a mathematics department? We navigate a bicultural world: one our professional life and the other our familial connections and cultural traditions. We maintain strong familial connections grounded in our cultural values and may at times forgo making progress on a research paper, attending a research conference, or taking on another project in favor of caring for a loved one, meaningfully engaging in a family event, or spending quality time with our family. The claim here is not that our colleagues would not make similar choices, but that those are considerations that weigh heavily on our minds, more often than not, when we make decisions that might differ from some of our colleagues. The conflict is the worry that the reasons for making the culturally-grounded choices may be misunderstood or be perceived as not being serious about our careers. Although elders in our families emphasized "cuide su trabajo" or "take care of your job" (because in their experience and reality, if you don't work you don't eat), sometimes meeting our professional responsibilities entailed making tough choices that run contrary to typical practices in our culture such as living far away from the extended family, not being able to be at the hospital when a loved one was admitted, missing family social events, etc.

The other culture we navigate is that of researchers and faculty members at a research-intensive university. Cribbs, Hazari, Sonnert, and Sadler [CHSS15] indicate that a positive sense of affiliation for mathematics or the development of mathematical identity is rooted in "opportunities…both inside and outside of the classroom that include experiences where students are *recognized* in mathematics" [CHSS15, p. 1060]. We were fortunate in that our mathematical identity developed from early successes and recognition in mathematics, albeit in underserved school environments. In addition, while we both pride ourselves in our ability to be resourceful and independent, we recognize the importance of mentors at key moments to promote talent in research or teaching, offer useful advice on essential aspects of navigating the tenure and promotion process, or provide guidance in grantsmanship. Without appropriate mentors and persistence, the friction between familial or cultural identity and professional mathematical identity may impede the necessary adaptations for navigating the mathematics profession. Additionally, balancing the tension created by maintaining focus on research expectations while simultaneously giving sufficient attention to broader outreach in the mathematical community can be overwhelming without a network of colleagues providing guidance about how to manage these complementary, but sometimes competing, goals. Our mentors and our own awareness helped us understand that our agency to effect change rested in doing solid work and focusing on key areas relevant to the evaluation of our performance and quality of our work. If, at times, our familial identity or origins might have put us in seemingly disadvantageous situations, having established a firm research identity helped overcome any powerlessness and made it possible to effect change.

What can mathematicians do to help students who perceive themselves as academically capable, had limited access to mathematical experiences that advance mathematical achievement, lack mentors and role models for "adding on" a mathematics identity to their cultural identity, and may feel powerless or invisible? This can be addressed by culturally relevant pedagogy which is distinguishable by "three broad propositions or conceptions regarding self and others, social relations, and knowledge" [Lad95, p. 483]. Some of these ideas were intuitive for us personally and largely derived from our own trajectories. Perhaps this contributed to our successes in the classroom as attested by the numerous teaching awards we each have earned, which include the highest honors in teaching at our institution and the University of Texas System.

The most salient aspects of Ladson-Billings's [Lad95] work regarding conceptions of self and others that are reflected in our own teaching are believing all students are capable of academic success in mathematics, seeing ourselves in our students and as part of a community, believing that teaching is a way to give back to the community, and embracing the idea that teaching is a process of extracting student knowledge and building upon it [Lad95, pp. 478–479]. Partly due to our own backgrounds and mathematical trajectories, we see broad benchmarks for where a student needs to be in terms of their mathematical development, say by a certain age or certain level. For example, James's high school did not offer calculus, and Minerva's high school did not offer a mathematics course

beyond Algebra II. Some might think that a student with this level of exposure may be too far behind and catching up would be insurmountable. Nevertheless, we do recognize that a student needs a plan or a roadmap to eventually obtain the mathematical foundations and mathematical habits of mind to be successful. When we embrace our historically marginalized ethnic and racial groups in our mathematical community, we are welcoming all learners as contributors in the learning environment. We are confident that our students already have important knowledge based in their experiences and backgrounds. Our job is to capitalize on this and help them construct their understandings. Genuine encouragement for solid mathematical ideas and conclusions is common in our classrooms because we put ourselves in the place of the student. We also strive to find ways to validate their assertions, given the status of their knowledge at the time, by practicing an asset-based approach to mathematics education (see also [CPBea18]). An alternate way to gain insight about the common mathematical experiences of STEM-bound students from minoritized groups is to spend time in ethnically and racially diverse public-school classrooms and connect with local schoolteachers who teach students from diverse populations. Also, involving students in classroom tasks that require active engagement and cooperative learning provide opportunities for understanding students' thinking and prior knowledge. This enables the instructor to determine questioning sequences, develop subsequent tasks, or find other ways to draw out insightful student thinking or comments. In their study exploring successful transitions into a university STEM program, Ulriksen, Holmegaard, and Madsen [UHM17] found that construction of disciplinary identity relies upon students' engagement with the curriculum as well as their prior knowledge and experiences.

With respect to social interactions, Ladson-Billings [Lad95] refers to teacher-student relationships that are equitable and reciprocal. We have a heightened awareness of the need to provide students the opportunities to collaborate, explain, and participate in their learning. In the classroom, this can be achieved by reflecting on: Who is being excluded in discussions? Who is isolating themselves during collaborative work? How can we connect students' mathematical understandings in productive ways? Who is struggling with the mathematics and in what way? Establishing a good rapport with students helps facilitate interactions that are equitable and reciprocal. Moreover, it enables instructors to ask students to expand, elaborate, and explore more mathematics in a safe and supportive way.

Student contributions and participation are a central part of our own teaching. This relates to the idea that knowledge is "shared, recycled, and constructed" [Lad95, p. 481]. Having students participate in the construction of a proof or sharing their ideas about subsequent steps to take or using strategies from previous proofs emphasizes the value placed on participation and engagement in the classroom. If everyone is expected to contribute and participate, this would certainly include students of color. However, developing an awareness for enabling diverse voices to be heard in the classroom is critical for ensuring that minoritized students participate at equitable rates. Also, providing multiple ways to assess students' knowledge and various ways of recognizing excellence empowers students to persist and experience satisfaction in their mathematics learning.

Identifying with our minoritized students (which, by the way, does not require one to be a member of a minoritized group) provides a powerful perspective for advocating for their success in mathematics, their inclusion in the scientific community, and their access to careers in STEM. Part of the process for identifying with them involves informal individual and small group meetings to learn about their views about your class and the university environment and to learn about their past experiences. Some questions we can ask: What am I doing in class that is working for you? What am I doing in class that is not working for you? What events on campus are important to you? How do you feel about recent events on campus? Tell me about your past experiences in mathematics? What strategies did your teachers use that worked well for you? What strategies did not work well for you? Both student confidence and persistence correlate with positive informal contact with faculty (see [KMB10]). Thus, we call for a commitment to finding ways to understand minoritized students' social and mathematical experiences and use these ways as an asset to support students in acquiring the tools to compete in academia or industry at a level that we would want for our own children.

Perhaps the "difference" between a mathematics major from a historically marginalized ethnic or racial group and other mathematics majors derives from the vastly different messages each has received about who can and cannot do mathematics? It is our collective responsibility to dismantle these messages through genuine encouragement, excellent teaching and mentoring, and providing opportunities for success. We call for *authentic* experiences for minoritized students of color that provide many opportunities to experience positive recognition in mathematics that legitimately fosters their mathematical identity.

While we acknowledge that there is no magic bullet or formula for increasing access and participation for students from minoritized ethnic and racial groups, some considerations that arise from our experiences coupled with interpretations from research-based frameworks in mathematics education are:

1. Recognize students' academic accomplishments. For example, acknowledge insightful ideas they offer in class or send them an email about it, or congratulate them on excellent performance on a homework task or an exam.

2. Interact with students in class and encourage them to attend office hours. For example, informal conversations that help instructors get to know their students are much more likely to take place during office hours. Praise their questions and take them seriously.
3. Adopt teaching strategies that encourage active engagement in the classroom and learn how to facilitate productive mathematics discussions and ways to monitor equitable participation by minoritized students.
4. Assign tasks that allow multiple entry points and look for ways to welcome contributions and build upon them.

Both mathematics majors from historically marginalized ethnic or racial groups and other mathematics majors share a love of mathematics and see themselves as "math people." Recognizing this, we can all capitalize on this common ground. We should treat students equitably by delving into their desire to move forward with mathematics but affirming that their experiences before and during our class may be quite different than their nonmarginalized peers and have nothing to do with the mathematics being taught. We all must give minoritized students equitable, rich mathematical opportunities and provide the support they may need for advancement.

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