A Mutual Benefit Approach to Address Systemic Underrepresentation in STEM Higher Education

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List of Acronyms

Acronym	**Explanation**
AA	Affirmative Action
CURE	Course-Based Undergraduate Research Experience
DBR	Design-Based Research
DEI	Diversity, Equity, and Inclusion
DISH	Deliberate, Institutional, Structural, and Historical
EEC	Engineering Ethics Collaboration
HBCU	Historically Black Colleges and Universities
HS	High School
IEEE	Institute of Electrical and Electronics Engineers
IRB	Institutional Review Board
K-12	Kindergarten to 12th Grade
MBA	Mutual Benefit Approach
MSI	Minority Serving Institution
NSBE	National Society of Black Engineers
PWI	Predominantly White Institution
SHE	STEM Higher Education
SHPE	Society for Hispanic Professional Engineers
SIEDS	Systems & Information Engineering Design Symposium
SRSE	Systemic Racism in STEM Higher Education
STEM	Science, Technology, Engineering, Math
SWE	Society for Women Engineers
URM	Underrepresented Racialized Minorities

Abstract

This Work-in-Progress paper presents ongoing research on the Mutual Benefit Approach (MBA), a strategy designed to address systemic underrepresentation of racially minoritized groups in STEM Higher Education (**SHE**). MBA conceptualizes systemic racism in STEM Higher Education (**SRSE**) as the underrepresentation of people of color in all aspects of the STEM enterprise in proportion to their presence in the general population. MBA is rooted in theories of social justice and equity, and targets the Deliberate, Institutional, Structural, and Historical (**DISH**) factors that perpetuate SRSE. The approach emphasizes multisectoral partnerships and immersive experiences to normalize diversity in SHE from K–12 through graduate school. We present preliminary results from three years of implementation in collaborative engineering ethics courses involving a Minority Serving Institution (**MSI**), A Predominantly White Institution (**PWI**), and K–12 public schools. These results indicate promising outcomes in student persistence and engagement in STEM. This paper outlines the MBA motivation, research design, and early findings, and discusses implications for addressing the inhibitive effects of SRSE on the participation and persistence of students from racially minoritized groups in SHE.

Keywords: Underrepresentation, Mutual Benefit Approach, Normalization, Self-Efficacy, STEM Higher Education

Introduction

African Americans and other People of Color are underrepresented in STEM Higher Education (SHE) and the workforce [1], [2]. McGee (2020) [3] uses the term Underrepresented Racialized Minorities (URM) to refer to these groups collectively. STEM is vital to the US economy and national security [4],[5], therefore including the missing millions of underrepresented people is critical for America's STEM workforce as the nation becomes more racially diverse [5],[6]. Furthermore, underrepresentation in STEM is a persistent, unresolved social justice issue in America [7]. Civil Rights, Affirmative Action, Title IX, and DEI (Diversity, Equity & Inclusion) are notable high-level approaches with differing degrees of direct attention to addressing underrepresentation in STEM. However, underrepresentation persists. The MBA project explores the use of multisectoral partnerships to address the root causes of SRSE, thereby increasing the participation and persistence of URM students in this critical sector. [8]

We use the term Mutual Benefit Approach (MBA) to characterize our work. MBA draws on Covey's win–win concept [66], which emphasizes trust-based relationships grounded in mutual benefit. Within this framework, trust enables partners to collaborate more effectively by developing a shared language across diverse backgrounds and interests. This shared understanding, in turn, supports sustained commitment to the partnership and fosters a collective sense of ownership over both the collaborative process and its outcomes [67].

Literature Review

MBA posits that underrepresentation is the result of Deliberate, Institutional, Structural, and Historical (DISH) policies and programs that have been racist in intent and effect [4],[9],[10] *Deliberate* refers to racially discriminatory policies and programs and previous attempts to remedy them, from the Slave Codes to "Separate but Equal," the Civil Rights Movement,

Affirmative Action, Title IX, and Diversity-Equity-Inclusion (DEI) [11]-[14]. *Institutional* refers to the implementation of exclusionary and unequal policies and programs across all levels of educational institutions from K-12 through Colleges and Universities [13], [15] that systematically denied URM students equitable access to STEM education. *Structural* refers to the pervasive and continuous presence of DISH policies across multiple sectors of society, including Education – in the form of school and teacher quality, Housing – in the form of segregation, redlining, and the unequal funding of public schools through property taxes, Employment – in the form of discrimination in hiring and firing, job type, and pay inequity, and in the Financial sector – in the form of access to financing for education and other purposes that affect household wealth [16]-[18]. *Historical* refers to the inception, spread, persistence, and legacy effects of the factors that underpin SRSE [19].

In addition to their external effects, DISH forces also exert internal influences on SRSE. In the internal case, *Deliberate* refers to the establishment effects of the White male as the standard of quality in STEM Higher Education (SHE) [20]. This is internal to the historical development and cultural construct of the STEM curriculum, the content of STEM textbooks, the representation of key achievers in STEM, and the representation and attitudes of STEM educators [20]. URM are not included in the White male standard and can internalize a sense of unbelonging [21] that expresses itself in such forms of inefficacy [22] as stereotype threat and imposter syndrome [23], [24]. Internally, *Institutional* refers to an exclusionary atmosphere at White STEM educational institutions, manifested in subtle modalities such as, microaggression, implicit bias, and the assumption of minority assimilation into the cultural norms at Predominantly White Institutions (PWI) [23],[25],[26]. Internally, *Structural* includes such issues as the differential levels of familial support for first generation students and students from lower-income or single-parent households and educational affordability [27],[28], which affects a student's ability to experience education on an equitable footing with their peers [29],[30]. Internally, *Historical* refers to the legacy effects of racist and exclusionary policies in the system of race-based slavery established in the early 17th century. These include the psychological effects of legal and policy challenges to programs such as Affirmative Action, Title IX, and teaching of American History [19],[31]-[33]. It includes violence and intimidation associated with White Supremacy, such as threats to HBCU campuses and repeated incidents of racial intolerance on PWI campuses [34]. These legacy effects are apparent in the lack of representation in STEM and limited aspirations of students toward STEM leadership in academia, industry, and government. Historical also includes the burdensome effects on self-efficacy in STEM imposed by racial segregation and inequity in housing, K-12 schooling, standardized testing, access to college, and the support necessary to graduate with a STEM degree [16],[17].

It is necessary to highlight the external and internal components of systemic racism in STEM Higher Education (SHE) because policies and programs that focus primarily on increasing the number of URM in STEM often are not crafted to address the role and effect of DISH factors on the experience of these targeted groups in SHE. Indeed, increasing the numbers of URM students in SHE is still pursued largely as an exercise in which they will assimilate into the STEM status quo that was established on a White male standard under racially biased conditions [35]. Thus, many programs pursue increased diversity in STEM without challenging the inhibitive and exclusionary effects of standards that dictate the curriculum, pedagogy, textbook content,

cultural bias in standardized testing, implicit bias in instructors and administrators, the lack of peer groups and representative role models along with other external and internal DISH factors that were discussed earlier [36]. Furthermore, few programs approach diversity in STEM as intrinsically beneficial to all the people and institutions involved in the enterprise [26]. Though the economic, strategic, innovation, commercial, social justice and other instrumental values of diversity are acknowledged, the benefits of immersion by White students and faculty in predominantly Black and Brown STEM institutions (HBCUs and other MSIs), with their distinct culture and traditions, is understated and overlooked at best [4]. This limits the opportunities for genuine, mutual, interracial partnership in changing the standards of quality and achievement in STEM from one that is exclusive and inhibitive to one that is deeply inclusive and permits the pursuit of STEM as an enterprise that taps the rich diversity of talent and experiences that is one of the greatest assets of the melting pot that is America.

There are several approaches to address underrepresentation in STEM. We consider those that are focused on SHE, which is the subject of this study. Evidence-based approaches in SHE include bridge and cohort programs, first-year learning communities, and summer bridge initiatives that support academic integration and self-efficacy when aligned with culturally responsive pedagogy [37],[38]. Mentored undergraduate research and Course-Based Undergraduate Research Experiences foster scientific identity and intent to persist, particularly when mentorship acknowledges racialized experiences [39]-[41]. Advising reforms—asset-based, intrusive/holistic advising—and supplemental instruction correlate with improved course completion and term-to-term persistence among URM students [42], [47]. Financial supports (e.g., last-dollar scholarships, emergency aid) directly mitigate affordability barriers and reduce stop-out risk [48]-[50]. Cross-institutional partnerships between MSIs and PWIs that enable reciprocal immersion, shared teaching, and mixed-team projects—central to the MBA approach—show promise for normalizing diversity, building trust, and supporting belonging and persistence [51]-[53],[54]-[56].

Affirmative Action (AA) expanded access for URM students and faculty, especially at selective institutions. It also catalyzed attention to inequities. However, AA alone does not address the underlying DISH factors that determine persistence and completion in STEM (e.g., inequitable K–12 preparation, hostile climates, financial precarity) [28],[31]-[33],[57]. Legal and political challenges to AA create volatility that constrains institutions' abilities to sustain long-term strategies and may dampen commitments to equity [28]-[30]. Diversity, Equity, and Inclusion (DEI) initiatives have increased training, compliance infrastructure, and some climate awareness. Yet outcomes are inconsistent when DEI is programmatic rather than structural—focusing on headcounts and workshops without redesigning curricula, assessment, resource allocation, and accountability for outcomes [58],[59]. Furthermore, recent restrictions on DEI by the federal government preclude this approach to addressing underrepresentation in SHE [60]. The literature increasingly argues that meaningful, durable change requires multi-level strategies that integrate admissions, pedagogy, mentoring, advising, financial supports, and cross-sector partnerships—such as MBA's trust-based, mutually beneficial model—to transform the conditions that produce underrepresentation [51].

Research Plan

The MBA research plan uses knowledge on the links between SRSE and underrepresentation in SHE to craft a strategic partnership aimed at mitigating the adverse effects of SRSE. MBA research seeks to answer four key questions:

1. What are the strategies that address the DISH factors (root causes) necessary to mitigate the negative effects of SRSE on URM student representation in SHE?
2. Can a strategy to normalize representative diversity in SHE mitigate the negative effects of SRSE?
3. How can such a strategy be implemented?
4. How can the effectiveness of such a strategy be assessed, evaluated, and disseminated to produce change?

MBA has two hypotheses. The first is that the adverse effects of SRSE ***can*** be mitigated. By this we mean that the negative effects on URM's self-efficacy in STEM can be countered and minimized (mitigated). The MBA project cannot change generations of personal beliefs and attitudes or institutional structures that underpin SRSE. However, we believe the project can illuminate the key factors and mechanisms of SRSE and craft an informed strategy to mitigate their negative effects on students using a multisectoral partnership deliberately focused on that goal [38,39]. This partnership brings the sectors of academia, community, industry, and government together to understand and craft effective approaches to mitigate the adverse effects of SRSE. Our ongoing work in this project is to build such a partnership from new and existing collaborative relationships working in different ways to counter the adverse effects of SRSE.

Our second hypothesis is that gradual and continuous immersion in STEM education in learning environments with diverse groups of students, educators, and mentors can normalize STEM Higher Education as a diverse endeavor. We arrived at this hypothesis after two years of observing classes of predominantly White students from a PWI and predominantly URM students from a MSI working together in an Engineering Ethics class taught jointly by the authors [54]. There is also a small body of literature that examines the effects of immersive experiences on normalizing intergroup interaction [55,56,61].

MBA Goal and Objectives

The MBA goal is to develop an effective approach to mitigate the effects of SRSE that lead to underrepresentation in STEM Higher Education. We seek to achieve this goal through three objectives:

i) Create a model collaborative project designed to counter the DISH factors of SRSE.
ii) Test the model's effectiveness and validate its approach.
iii) Disseminate the results for peer review and possible broader adoption.

An Engineering Ethics Collaborative (**EEC**) course between the MSI and PWI is a key element of the model. Another major facet of the model is the multi-sectoral partnerships that focus on different dimensions of SRSE. This will be described briefly below.

The sustained vitality and support for the partnership, the EEC, and other dimensions of the MBA model are preliminary evidence of the validity of the MBA approach. Work is ongoing on formal methods of assessment and evaluation of the MBA model. Scholarly publications and replication of the MBA model at a second institution are preliminary steps at dissemination of the MBA model. These are discussed further below.

We achieve the MBA objectives through four main activities, each of which serves the three objectives:

A1. Address the **Deliberate** DISH factor with ***Intentional*** Design of the MBA model. This includes a Design-Based Research approach focused on mitigating the negative effects of SRSE on student engagement and persistence in SHE [63]-[65].

A2. Address the **Institutional** DISH factors with ***Institutional*** partnerships. Coordinated to counter SRSE. This involves K-12 public schools, a community college, a 4-year MSI, and a 4-year PWI. The K-12 partnership was limited to 4^{th} – 12^{th} grade because we were initially motivated by the disproportionate results of URM students on STEM subjects in State Standard of Learning (SOL) tests, beginning at the 4^{th} grade level.

A3. Address the **Structural** DISH factors with ***Sectoral*** partnerships coordinated to counter SRSE. The sectors are:

- Academia – including students, teachers, faculty, and college student organizations.
- Community - including the family of students participating in MBA activities, community groups that host activities and provide financial support to students, and churches that help to host activities and mentor students and their families.
- Industry –local businesses that provide financial support for MBA activities.
- Government – including the local school boards that provide logistical support, such as school buses and access to public schools for tutoring by college student groups. The mayor's office which provides approval for access to public offices and spaces for field trips as well as letters of support for research funding proposals.

A4. Address the **Historical** DISH factors with a ***Pipeline*** system designed to counter SRSE "*from grade school to grad school*." Students would progress through each level of MBA activity to matriculate in STEM (preferably, though any college major is acceptable). Activities include:

a. Programs for 4^{th} – 12^{th} grade; "*from awareness to agency*." These include:
    i. Saturday morning lab tours. Two, 50-minute tours of labs in the Engineering school of the PWI hosted by the faculty and graduate students in charge of the labs. These are intended to raise student awareness of STEM and its practice through hands-on demonstration activities in each lab. Tours are held on 6 Saturdays each Fall. The program began in Fall 2018, was interrupted by COVID-19 in Fall 2020, and resumed in Fall 2021. The tours have averaged 30 students from multiple demographic groups each Saturday, with a single-day high of 86 students in Fall 2019 when school buses were available, and a single-day low of 6 students in Fall 2025. College student group members, such as C-100, NSBE,

SHPE, and SWE help to coordinate the lab tours and guide the visitors around campus.

ii. M-Cubed Academy focused on intensive mentoring and Math preparation for Black young men from 4^{th} – 10^{th} grade. This activity includes 90-minute Math tutoring activities online each Monday evening with a professional instructor and guest visits by partner faculty, community, business, and government officials. Also included is a two-week summer academy for Black young men from rising 4^{th} – 10^{th} grade. This provides intensive Math instruction and practice to prepare the young men for their upcoming school year.

iii. The Engineering Ethics Collaboration (EEC). This involves graduate students from the PWI, undergraduate students from the MSI and selected public high school students from the local region of the PWI. The college students share course activities in their respective Engineering Ethics courses, which are offered in the Spring semester on the same days and times each week at the MSI and PWI institutions. Shared activities include joint guest lectures by invited industry speakers, and a course project in small mixed teams of students from each institution. Also included on each team of 4-5 college students are 2 high school students per team. The high school students come from all demographic groups. This activity helps to build agency and self-efficacy across all students for successful, normalized engagement and success in STEM as an activity with diverse participants.

Preliminary Results

Results from Objective 1 – A Model to counter the DISH factors of SRSE.

The MBA model developed over 10 years as an informal, trust-based partnership between agents from different sectors working to improve the engagement and retention of students in SHE. Formal research on MBA began in Fall 2023 with a focus on understanding the DISH factors of SRSE and how the MBA could mitigate their negative effects on URM students. The sustained multisectoral partnership, academic programming, emerging research on - self-efficacy, program assessment, and evaluation - and preliminary scholarly publications on MBA are indicators that the model is robust and has the potential to counter the DISH factors that are the root causes of persistent underrepresentation in SHE. Observations of student productivity and uneventful interactions in diverse demographic group activities offered by the MBA program are preliminary indicators that immersion in these diverse settings may normalize STEM as a diverse activity for students. Further study, including comparison with control groups, would be necessary to confirm this conclusion.

Results from Objective 2 – Test the Model & Validate the MBA.

We use three indicators for preliminary validation of the MBA model: i) Are we able to sustain the partnership? ii) Are students progressing through the academic levels to matriculate in

college (preferably in STEM)? iii) Do MBA students from all demographic groups work well together on STEM activities?

In response to the first question, the partnership has remained stable and even grown since it began in 2015. Table 1 summarizes the members of the partnerships. Participant groups will be named in the published version of this paper.

Table 1. MBA Partners (bold letters indicate partners who joined between 2015 - 2018).

Academia	**Community**	**Industry**	**Government**
7 Elementary Schools	**1 Church X**	**Small Business1**	1 City Mayor
7 Middle Schools	**Pastor1**	Small Business2	1 City School Board
8 High Schools	Pastor2	Small Business3	**County School Board1**
7 Public School Science Teachers	**2 Community Org1**	**Guest speakers1-5**	County School Boards2-7
1 Community College	Community Org2	Guest speakers6-20	
1 MSI w. 2 faculty	1 Labor Union		
1 PWI w. 1 faculty			
15 PPWI lab faculty			
4 PWI student groups			

Table 2 summarizes the number of students participating in MBA activities and those matriculating to college in Engineering. Lab Tour and M-Cubed student counts include students who participated in Lab Tours on multiple Saturdays and/or also participated in M-Cubed activities. Therefore, there is some double counting in these numbers. All the numbers in Table 2 are close estimates since not all students reported their acceptance to college or the major they selected. The actual number of students is likely higher in each case.

Table 2. Number of Students Participating in MBA Activities (2021 – 2025).

Metric	**2021-22**	**2022-23**	**2023-24**	**2024-25**
# Grade School Students[1] - Lab Tours + M-cubed	~130	~123	~64	~64
# MSI Students in EEC Class	-	23	21	17
# PWI Students in EEC Class	-	17	20	15
# HS Students in EEC Project	-	12	12	0
#Student Organization Students	6	11	5	6
# HS Students entering college ENG	4	5	4	7
[1]Double counting students who attended multiple Saturday Lab tours.				

- EEC – Engineering Ethics Collaboration – Class offered jointly by MSI & PWI partners.
- HS – High School

We did not have an IRB protocol approved for this project at the time of recording these data. That IRB application is now in process. Thus, we were unable to survey students about their experience participating together in the lab tours, working together on mixed teams on the EEC course, and receiving specialized attention as a group of Black young men in the Monday night

Zoom sessions and the Summer Math Academy conducted by the MBA community partner. However, our subjective assessment of "normalization" based on student interactions in the diverse group activities showed that the students worked in groups without hesitation or any significant inhibitions due to their demographic differences. Surveys and other instruments are needed to define this assessment in more objective terms. Nevertheless, it seems like participating as diverse teams on STEM activities was "normal" for the MBA project students, indicating that immersion in such groups might be an effective normalization strategy.

Results from Objective 3 – Disseminate the results.

We have three metrics for dissemination of the MBA project results. These are the number of peer-reviewed articles published by MBA participants, the number of external grants procured for MBA research, and the extent to which the MBA project is replicated in other locations. Table 3 summarizes these results from 2023 – 2025.

Table 3. MBA Publications and External Proposals Submitted (2023 – 2025)

Item	**2023 - 24**	**2024 - 25**	TOTAL
By MBA faculty and partners	1 ASEE regional conf. paper	1 ASEE regional conf. paper	2
By EEC Students	8 IEEE SIEDS	11 IEEE SIEDS	19
MBA Proposals submitted	1 NSF (declined)	1 NSF (declined)	2

The project received $55,000 in internal funding from the provost's office of the PWI in 2022 to cover a period of 2 years. MBA community partners also received significant funding from their external grant proposals. Those figures are not included here.

The MBA project is currently being adopted by the MSI partner to serve its local community with the full suite of MBA activities. This is another form of dissemination of MBA.

The MBA program is also disseminated informally through its student graduates who take its results to the colleges at which they matriculate for undergraduate and graduate study.

Discussion

Much has been written about the causes of underrepresentation in STEM Higher Education by URM students [62]. However, there is much less published work on systematic and effective methods to address this underrepresentation at its root causes. High-level policies and programs like Civil Rights Laws, Equal Opportunity and Affirmative Action, and DEI do not directly focus on the DISH factors of SRSE as they pertain to underrepresentation of URM students in SHE. The MBA project seeks to create a model that addresses the DISH factors of SRS that contribute to underrepresentation of URM students in SHE and inhibit their persistence in STEM fields. MBA uses *Intentional* design to address the Deliberate DISH factor of SRSE, *Institutional* collaboration to address the Institutional DISH factor, *Sectoral* partnerships to address the Structural DIS factors, and a *Pipeline* system from grade school to grad school to address the Historical legacy DISH factor of SRSE. MBA was developed over 10 years as an informal project between a group of partners committed to improving the engagement and success of URM students in SHE and the STEM workforce. This trust-base partnership led to a series of

academic and shared community activities that helped to build students awareness of and self-efficacy ("I can do it!") in STEM education. The informal project is now being established as a formal research program to achieve the MBA goal. As MBA transitions from an informal project to formal research, it will need important research instruments and partners:

i. An approved Institutional Review Board protocol to conduct surveys and other research activities involving the students and other partners in MBA program.
ii. Methods for assessment and evaluation of the effectiveness of the MBA program, including testing of its two hypotheses.
iii. Control groups of students to compare the effectiveness of MBA activities. This includes performance on STEM subjects on the SOL tests for 4^{th} – 10^{th} graders, college matriculation rates (including STEM majors) for 12^{th} graders, perceptions of their experiences in diverse group immersion activities, and rates of entrance into STEM graduate study or the STEM workforce.
iv. Addition of an educational psychologist to guide the study of self-efficacy and its effects on URM student engagement and persistence in STEM. A PhD student at the PWI is currently working on self-efficacy in STEM. This student is a graduate of the MBA EEC course.

Conclusion

MBA seeks to normalize engagement and success in STEM at all levels, from grade school to grad school and the workforce, as an activity in which students of all demographic groups are represented, at least, in the numbers proportional to their presence in the general population. Multiple DISH facets of systemic racism in STEM Higher Education have conspired over time and against previous efforts to prevent this. MBA provides a framework for mitigating the adverse effects of these DISH factors through *Intentional*, *Institutional*, *Sectoral*, and *Pipeline* partnerships and immersive experiences. Continued research will strengthen evidence for the effectiveness of MBA and inform its broader implementation.

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