ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #40935

Ethics Case Study Project: Broadening STEM Participation by Normalizing Immersion of Diverse Groups in Peer to Near Peer Collaborations

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Abstract

To successfully broaden the participation of underrepresented racially minoritized students in science, technology, engineering, and math (STEM), students from all demographic groups must routinely work together in STEM as a cohesive community. A Mutual Benefit Approach (MBA) is a way to create longstanding partnerships between members of the community, academia, non-governmental organizations (NGO) to develop equitable opportunities for students from all demographic groups to engage together in STEM. One of the primary objectives for MBA is to provide a continuous series of immersions in deliberately diverse STEM environments for students from K-12 up through the PhD. This will normalize STEM as a diverse experience for students and build their self-efficacy in STEM. The MBA also hypothesizes that peer to near-peer interactions are critical for students to progress continuously through all the levels of STEM, from K-12 to the PhD and STEM workforce. This paper discusses one example of a "normalizing immersion" – a team-based case study project in Ethics. The teams consisted of African American high school students, African American undergraduate students from a Historically Black College or University (HBCU) – Hampton University, and predominantly White graduate students from a PWI – University of Virginia. Student teams were guided by high school teachers in the Charlottesville Virginia area, university faculty members and community mentors – a holistic approach involving STEM in the context of students' respective communities. The team-based Ethics case study project included visits and campus tours at both universities with opportunities to eat in their dining halls as well as delivering presentations on their work. The paper discusses the methodology employed in the Engineering Ethics case study project, as well as planned future work to expand the project and improve it for the next iteration.

Introduction

Summary of STEM Status for African Americans

In 2021, 24% of all US jobs were in the STEM workforce[1]. STEM is vital to the US economy and national security[1,2]. Furthermore, diversity has been shown to enhance all aspects of the STEM enterprise[3]. And yet African Americans and other People of Color are underrepresented in STEM education and the workforce[4,5]. In 2021, African Americans represented 12% of the total US population but only were 9% of the STEM workforce, and 9% of STEM graduates[4].

Since many colleges banned race-based affirmative action, enrollment by African Americans and other minorities has dropped by 12%[6]. To compound problems, retention of African American students in engineering in 2015 was less than half that of white students[7]. Underrepresentation in STEM is a persistent, unresolved social justice issue in America that needs to be addressed systematically[8].

Mutual Benefit Approach

To successfully broaden the participation of minority students in the STEM field, representation from all the groups in that pipeline must be included and ideally work together as a cohesive community. A Mutual Benefit Approach (MBA) is to create a longstanding relationship with various stakeholders in the community, academia, and industry to create a pipeline for minority students in STEM. The MBA provides a series of normalizing immersions from K-12 up through the PhD in deliberately diverse STEM environments. The concept is from Garrick Louis who has brought together high school teachers, mentors from non-governmental organizations (NGO), and faculty from a Historically Black College or University (HBCU)[9]. The collaboration allows students to engage in a diversified classroom environment online, while remaining physically at their respective institutions. The intent is to build relationships between faculty and students at the respective institutions that could lead to other forms of collaboration, including joint research projects and opportunities for graduate study at the PWI for students from the HBCU, where there is no graduate program[9].

The Mutual Benefit Approach (MBA) project conceptualizes systemic racism in STEM education as the underrepresentation of people of color in all aspects of the STEM enterprise in proportion to their presence in the general population. MBA posits that this underrepresentation is the result of Deliberate, Institutional, Structural, and Historical (DISH) policies and programs that have been racist in intent and effect[10,11,12]. Deliberate refers to racially discriminatory policies and programs and 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)[13]. 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[14]. 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[15,16,17]. Historical refers to the inception, spread, persistence, and legacy effects of the factors that underpin systemic racism in STEM education[18].

Immersive Experiences

To combat systemic racism requires the breakdown of barriers between institutions and communities by working together out of our personal space and within the comfort zone of the other group. It is critical that long lasting relationships are formed from all the communities and organizations along the STEM pipeline and that each group has a voice and a say within the MBA framework.

Our hypothesis is that gradual and continuous immersion in STEM education in learning environments with diverse groups of students, educators, and mentors can normalize STEM education as a diverse endeavor. We arrived at this hypothesis after two years of observing classes of predominantly White students from PWI, the University of Virginia (UVA) and predominantly Black students from HBCU, Hampton University, work together in an Engineering/Research Ethics class taught jointly by the co-authors[9].

There is also a small body of literature that examines the effects of immersive experiences on normalizing intergroup interaction[19,20,21]. This suggests that the immersion strategy is worth investigating.

About half of the engineering graduates from Hampton University go on to graduate school. These students all have one or more summer research experiences at PWIs thanks to NSF REU programs and other similar programs. The students see themselves doing research in PWI labs and feel comfortable in that atmosphere due to the immersive summer research internships.

Ethics Case Study Project Methodology

Hybrid Ethics Class Collaboration Between PWI and HBCU

Ethics guides all aspects of an engineer's job from proper safety, process and product design and quality management[22]. Products and their contents, uses, and potential hazards must be properly disclosed and labeled[9]. Engineers also have an ethical responsibility to credit intellectual property both within and without the company[9]. A growing number of corporations have an Ethics Officer[23,24]. Every Professional Engineer is required to take an Ethics course every 2 years[25] and each professional society has its own code of ethics[26,27,28].

A community of practice has been developing over the past 2 years through a collaboration between University of Virginia (UVA) and Hampton University (HU) featured in this paper[9]. The collaboration started through joint engineering ethics courses being taught at the same time so that lectures and outside seminars of common interest were shared in a hybrid learning environment through Zoom and Blackboard for mutual benefit[9]. It was considered a Mutual Benefit Approach (MBA) to begin a natural collaboration between instructors, students, and institutions towards an increased diversity of environments and ideas. The UVA course was directed to graduate level students in engineering, and the HU course was for undergraduate engineering students. Initially, 4 seminars were shared between the two courses covering Professional Engineering Code of Ethics, Corporate Ethics, Quality and Compliance, Intellectual Property, and Climate Ethics[9]. In the subsequent year, the collaboration expanded with the goal to further relationships between faculty and students that could lead to other forms of collaboration, including joint research projects, opportunities for graduate study and other mutual benefits. The current collaboration resulted in an internal grant from UVA to support one-day in-person student exchange visits to expose students to diverse environments, giving many students their first experience at a PWI/HBCU campus, respectively, to foster fluency in operating in a real-world multiracial STEM environment. This endeavor further tapped into existing relationships with community, industry, and government partners, including the local chapter of an NGO, 100 Black Men of Central Virginia. HU faculty presented to the organization's K-12 student group. Furthermore, students from three local High Schools near UVA including co-author LaNika Barnes of Albemarle High School joined the collaboration with the support from the 100 Black Men of Central Virginia. As a result, the second iteration of the engineering ethics course collaboration included the participation of High School students, their STEM teachers, the NGO, and industry partners as speakers, mentors and financial supporters to provide a broader context for the STEM experience for the students. All of the stakeholders are represented in the authorship of this paper.

High School Students Local to PWI

Charlottesville High School (HS1), according to the 2022-2023 Virginia Department of Education's School Quality Profiles (HS1SQP), accommodates approximately 1,200 students, offering a diverse range of educational opportunities[29,30]. The school provides access to 28 college-

level courses, featuring programs like an engineering curriculum and the Sigma Lab, dedicated to fostering coding and engineering skills[29]. The school has a racially diverse student body, with 41.9% White, 28.9% Black, 14.2% Hispanic/Latino, 4.5% Asian, <1.0% Native American, and 10.3% identifying as Multiple Races[29]. Nearly half of the student population (48.6%) falls under the economically disadvantaged category[29].

Academically, the school demonstrates notable achievements, boasting a 92.9% on-time graduation rate[29]. A significant portion of its students (28%) takes at least one Advanced Placement (AP) exam, with 75% achieving scores of 3 or higher[29]. Examining state-mandated exams, data from the HS1SQP indicates an overall pass rate of 70% for secondary science courses (Earth Science, Biology, and Chemistry), surpassing the state average of 67%[29]. However, it's crucial to acknowledge variations among specific demographic groups, as students who identify as Asian, Black, and Multiple Races scored below their peers across the state.

Albemarle High School (HS2), as per the 2022-2023 Virginia Department of Education's School Quality Profiles (HS2SQP), accommodates approximately 2,000 students and provides a diverse cadre of educational offerings[29,31]. HS2 provides over 25 college-level courses and features programs like AVID (Advancement Via Individual Determination) and the STEM (Science, Technology, Engineering, Math) Career Learning Community, open to all HS2 students as well as those through the shared school division[29].

Demographically, the student body at HS2 breaks down as follows: 49.4% White, 16.9% Black, 18.9% Hispanic/Latino, 7.9% Asian, <1.0% Native American, and 6.8% identifying as Multiple Races[29]. About 33.2% of the student population falls under the economically disadvantaged category[29]. Academically, HS2 maintains a 92.0% on-time graduation rate, just below the 94% division rate but aligning with the state rate of 91.9%[29]. Approximately 27.5% of students are enrolled in at least one Advanced Placement (AP) or Dual Enrollment (DE) class[29].

Examining state-mandated exams, data from the HS2SQP indicates an overall pass rate of 64% for secondary science courses (Earth Science, Biology, and Chemistry), falling below both the state and division rates, both at 67%[29]. Notably, variations exist among demographic groups, with Black students having a pass rate of 40%, higher than their division peer groups but still below the state average[29]. Hispanic students demonstrate a passing rate of 38%, slightly lower than their division peers (39%) and below their state peers (52%)[29].

Monticello High School (HS3), as per the 2022-2023 Virginia Department of Education's School Quality Profiles (HS3SQP), accommodates approximately 1,178 students[29,32]. HS3, much like the other high schools in the area, provides students with a diverse program of academic studies but also emphasizes the opportunities in the areas of arts, technical education, and vocational courses. HS3 also encourages their graduates more so than some of the area schools to enroll in college courses at the local community college as well as to engage in coursework that leads to certifications and on-the-job training at the local career and technology center.

Demographically, the student body at HS3 breaks down as follows: 60.6% White, 12.2% Black, 17.0% Hispanic/Latino, and 7.0% identifying as Multiple Races[29]. About 35.9% of the student population falls under the economically disadvantaged category[29]. Academically, HS3 maintains a 94.8% on-time graduation rate, which is just above 94% division rate and is above the state rate

of 91.9%[29]. Approximately 27.5% of students are enrolled in at least one Advanced Placement (AP) or Dual Enrollment (DE) class[29].

Examining state-mandated exams, data from the HS3SQP indicates an overall pass rate of 58% for secondary science courses (Earth Science, Biology, and Chemistry), falling below both the state and division rates, both at 67%[29]. Notably, variations exist among demographic groups, with Black students having a pass rate of 44%, higher than their division peer groups but still below the state average[29]. Hispanic students demonstrate a passing rate of 37%, slightly lower than their division peers (39%) and below their state peers (52%)[29].

All three high schools in the area boast programs that emphasize and promote the inclusion of STEM education for their diverse student populations. HS2 was the site of their school division Math, Engineering, and Science Academy (MESA) for more than 10 years prior to the shift from academies to the STEM Career Learning Clusters (CLCs) during the 2023-2024 academic year, which still maintains a rigorous yet accessible pathway for a diverse group of students to access the curriculum. This school is also the hub of the collaborative NSBE (National Society of Black Engineers), Jr. Chapter which is supported by the local UVA's NSBE PCI (Pre-College Initiative) Chapter. HS2, much like HS3, was the site of their school division's Health and Medical Sciences Academy which has now become a similar CLC where students are challenged to complete high-level math and sciences courses during their four-year commitment. Lastly, HS1, which is not a part HS2 and HS3 school division but located in the same area, has invested in state-of-the art engineering labs in which students are supported by the same UVA as they complete a five year, engineering focused curriculum that culminates with a capstone project.

Minority Serving NGO: 100 Black Men of Central Virginia

The Sentara 2022 MAPP2Health report highlights the urgent need to address racial inequities in education, socio-emotional health, and financial stability[33]. In the specific context of the HS1 and HS2 communities in UVA's general community, there is a pressing demand for mentorship, literacy, math, and financial literacy programs. These programs are crucial for tackling the diverse challenges and disparities that exist in the region, ultimately contributing to the overall well-being and future prospects of individuals and families.

Within HS1 and HS2, numerous young people confront obstacles related to academic achievement, personal development, and decision-making. Economic disparities in these areas disproportionately impact marginalized communities, reflecting a broader trend observed in many regions. To address these challenges, the implementation of free and low-cost peer-to-peer and near-to-peer collaborative programs is recommended. These initiatives can offer guidance, support, and role models, assisting young individuals in navigating the complexities of adolescence.

To bridge existing gaps, it is essential to establish programs that actively involve middle and high school students, as well as their families, with working professionals, professors, and undergraduate and graduate students from colleges and universities. This collaborative approach

represents a significant step towards providing emotional support and encouragement, aiding individuals in coping with life's challenges[33]. Moreover, a considerable number of the young people supported by these initiatives struggle with basic literacy skills, limiting their access to education, employment opportunities, and effective community engagement. Therefore, ensuring ready access to focused activities within the community becomes pivotal for enhancing academic and career readiness and improving long-term educational outcomes.

Overview Collaborative Ethics Case Study Project

The collaboration expanded to include a 4-week multi-level exercise, focusing on Engineering Ethics and Safety, with students from three participating High Schools near to UVA as well as UVA and HU students. The high school students were chosen based on demonstrated academic excellence and an expressed desire to pursue Engineering as a field of study after graduation. The objectives for high school students working with graduate and undergraduate students were to:

- collaborate on a series of projects, designed to explore their interests in field of engineering.
- challenge their academic aptitude through problem solving and teamwork building.
- take part in a campus tour and have discussions with professors, students and professionals.
- grow their interest in the field.
- present their team projects for evaluation at the end of the collaboration.

Ethics Case Study Topics and Their Selection

Students were provided a Google form that had 12 topics for ethics case study projects. The students were to pick their top five projects out of the list. To assist the students in understanding the topics a base reference for each topic was provided for them to read if desired. Out of these 12 topics 9 were selected. The selection was done on a first request basis. Each team was then filled so that had 2 to 3 HBCU undergraduate students, 2 to 3 PWI graduate students and one African American high school student. In the end the AI Chat GPT and AI Algorithm Bias were considered similar enough to combine and let students decide which of the two areas they would focus on which they chose the Algorithm Bias more than the writing tool. Since topics were chosen by first individuals finishing the assignment not all the topics chosen necessarily represented the overall interest of all the participating students. The students filling out the form were 38 out of a total of 46 or 82.6%. The breakdown of students who stated their preferred topics was 17 (85%) from HBCU, 9 (100%) from high school, and 12 (70.6%) from PWI. Over 90% of the students who filled out the form got one of their top three choices. See table 1 below for more information on topics and student choices. In the end, those not chosen were Drone Use and Global Justice, AI and Written Papers ChatGPT, and Flint Michigan Water.

Table 1: Ethics Case Study Topics

	% Student Choices

No.	Topic	1st	2nd	3rd	4th	5th
1.	Tuskegee Experiment[34]	10.5	15.8	15.8	5.4	10.8
2.	Drone Use and Global Justice[35]	5.3	2.6	7.9	13.5	5.4
3.	AI and Algorithm Bias[36]	5.3	7.9	2.6	2.7	8.1
4.	AI and Written Papers ChatGPT[37]	0	10.5	7.9	10.8	10.8
5.	E-Waste in Ghana[38]	10.5	10.5	13.5	13.5	10.8
6.	Engineering for Planned Obsolescence[39]	10.5	10.5	7.9	5.4	2.7
7.	Henrietta Lacks and HeLa Cervical Cancer Cells[40]	26.3	10.5	7.9	5.4	2.7
8.	Flint Michigan Water[41]	2.6	10.5	15.8	8.1	10.8
9.	Boeing Ultra Max Plane Crashes[42]	13.2	0	10.5	13.5	13.5
10.	Solar Panels and Sustainability Analysis[43]	10.5	7.9	2.6	2.7	13.5
11.	Facebook Privacy Breach[44]	7.9	5.3	7.9	13.5	5.4
12.	PFAS: Per- and Polyfluoroalkyl Substances[45]	2.6	7.9	5.3	5.4	5.4

HBCU Visit and Preliminary Presentations

The table below gives an outline of the day at Hampton University. The travel between institutions is three hours. This was the first day where group team members met each other.

Table 2: HBCU Day Timeline

Time	Activity
10 AM	High School and UVA Students Arrive at Hampton University
10-11 AM	Student introductions. Preliminary discussion of engineering ethics project. Agreed Rules of Engagement
11-12 PM	HU students give guided tour of their campus
12-1 PM	Lunch in Hampton University cafeteria
1-2 PM	HU and UVA students work on project
1-2 PM	High School students meet with HU Admissions Officer
2-3 PM	Teams give preliminary presentations on projects and plans for completion.
3-3:45 PM	Wrap Up proceedings

Some students could not attend due to illness or other activities they could not miss. All high school students did attend as well as some parents, teachers, and mentors from Nongovernmental groups assisting Black students to get into STEM fields. Missing students came from PWI and

HBCU. A couple of students who could not attend in person joined their groups online via Zoom and worked in breakout rooms. The Hampton University Dean of the School of Engineering Architecture and Aviation stopped by to welcome everyone and heard most of the preliminary presentations given by the teams.

PWI Visit, Rubric, and Final Presentations

The visit by the high school students and the HBCU undergraduates to University of Virginia was similar to the HBCU day including campus tours, meeting with campus officials involved in admissions or support of minority students at UVA and having lunch in the University of Virginia cafeteria. The highlight was the groups providing their ethics case study presentations which were outstanding. 100 Black Men of Central Virginia awarded the high school students with certificates and provided box dinners for everyone in attendance. Final words were given by faculty, mentors, teachers and some students.

A Google form rubric was provided to all in attendance to evaluate each talk for its content, organization, and teamwork (see Table 3).

Results & Discussion

HBCU Day

Overall the day at the HBCU went well. This was the first time that all three high schools participated in an activity together. The teachers, mentors, and parents of some of the high school students had a lengthy chat discussing the day and the ethics case study projects which was overwhelmingly supportive. The problems that did occur were mostly logistical in nature due to not having planned and started this as a group sooner with all supervisors involved. Participants' assignments to teams were in some cases last minute for those that had not chosen any topics. The concept and teaching of a group contract was not necessarily familiar to all of the students not from Hampton University. Some groups were shorthanded due to lack of attendance, but by giving all the students a good base reference, everyone who participated at the HBCU day did a great job in their preliminary presentations. The high school students did very well, and for many groups the topic was one of their top choices, so the students demonstrated real enthusiasm for the case study they were working on as a group.

Teamwork and Preparation

This was the biggest struggle for some groups: to get together virtually, assign tasks, and have everyone do them in a timely manner. Most groups used shared Google docs and slides. One group did its work in Canva. The biggest issue was choosing times that worked for all the team members. High school students have such an earlier timetable than the undergraduate and graduate university students that having a late meeting at night is not a great solution nor necessarily feasible. The need for all teams to do group contracts prior to or at completion of the HBCU visit. Part of these issues too was having all the supervisors working more coherently. Teachers and mentors were brought in late and did an amazing job helping out but having them on board from the beginning would have helped the team’s work more efficiently. Even though teams could have worked more cohesively there was sufficient time that all in the end did an

excellent job, and had done more than adequate research for their case study with additional references.

A supervisors' survey was given to the students a week prior to the final presentations as a Google form to determine how the groups were progressing. Only 16 of the participants filled it out although almost all groups were represented by those 16. Out of those 15 stated their groups had completed their group contracts; all had completed draft of their presentation; 14 had defined roles for each team member in the presentation; all had found their required additional references; and only 10 had identified their stakeholders for their case studies. Again, in the future, the group contracts are due as soon as possible. And in addition, have a survey earlier than last week and possibly a second one later to make sure folks feel comfortable and on track.

PWI Day with Final Presentations

Due to not having enough time allotted at University of Virginia with tours and meeting special counselors who work with Black students at both undergraduate and graduate levels at UVA, the talks were allotted 15 minutes each from the 20 minutes the students had practiced for prior to the visit. For some groups, individuals who could not attend in person joined in hybrid fashion to present over Zoom with their groups. Still, even with these added hurdles, the actual work done by each group was outstanding.

A Google Form rubric was available for all students, teachers, mentors, etc. to evaluate each presentation done. 17 people participated and evaluated each project. Each topic was given a value from 0 to 5 scale with 5 being highest. Explanations for low and high ranges given for each topic. For example, in Stake Holders, a top mark of 5 would be the following: "The students understand the complete scope of the case and all the parties affected by it. Determines all who should be involved in the decision-making process and their viewpoints."

Table 3: Final Presentation Rubric and Scores

Rubric Topic	Weighting	Google Form Evaluation Statistics Average (Std Deviation)
Overview Summary Case Study	20%	5.0 (0)
Stake Holders	10%	4.82 (0.39)
Ethical Issues	30%	4.76 (0.44)
Question and Answer	5%	5.0 (0)
Organization and Progression of Thought	5%	4.88 (0.33)
Data Presentation and Slide Quality	5%	4.82 (0.39)
Team Participation	10%	4.65 (0.61)
Citation of Information Sources	15%	4.65 (0.61)

Overall, all the presentations were outstanding. Each high school student contributed as much or more than the other team members in the presentations. The average scores were very high across the board.

Teachers wanted to present a case study of their own too but no time was available for them to do so. All participants get an opportunity to see the HBCU and PWI but sadly not the high schools and the work that they are doing there with their students, especially with engineering specialties offered at some of the schools. The mentors from 100 Black Men of Central Virginia also did not get much chance to speak and discuss their work in depth to the HU and UVA students. Perhaps those can be done in a hybrid fashion in the future iteration.

Future Work and Conclusion

For the next iteration, the goal is to expand the program to include two to three times the number of high school students. Have teachers and mentors involved early in the process. Have topics and group contracts chosen and completed prior to HBCU day. Considering the quality of the work and the interest of the ethics case study topics, the goal will be to try and have a larger audience of people to attend the final presentations to include students, faculty and administrators too. Need to include pre and post surveys of the participants to see how their personal views and understanding of the other groups may have changed from the case study project, and their knowledge of ethics in general has improved.

At UVA, there is an undergraduate and master student conference dealing with system engineering and design. The goal is to take advantage of this opportunity and have our ethics case study teams go through the whole conference process from writing an abstract to a conference paper and then a presentation at the conference itself. The authors have met and discussed this opportunity and think it is simply too good to not pursue fully. An initial timeline for the ethics case study project next year has been developed with the conference in mind so that abstracts and paper submissions can be turned in initially as drafts that can be graded and reviewed and redone prior to submission to the conference. This expansion of the ethics case study project to now include a written abstract and conference paper will be reflected in the syllabus for both HU and UVA ethics courses. It will be a lot more work for the faculty, mentors and especially the high school teachers. But the opportunity to give the students especially the high school students a chance at a peer reviewed conference publication and presentation is simply too special to not pursue.

For other schools and universities wanting to do this, a lot can be done online and in a hybrid fashion with all participants. That said the biggest issue still will be proximity of the groups to meet one another physically. The authors feel strongly that it is paramount that the PWI students walk and eat at an HBCU to be immersed in that different environment. Likewise for the high school students and HBCU students to do the same when visiting the PWI. The hope is that these normalizing immersions help foster a sense of belonging and respect from all parties and help generate peer to near peer relationships.

Overall, the Mutual Benefit Approach, involving all the stakeholders along the STEM pipeline from high schools, mentors, undergraduate and graduate faculty and students has been very

rewarding. Our objective is to add to the normalizing immersive experiences between all groups beyond the ethics case study project and have written joint grants towards this goal.

Acknowledgments

Authors would like to acknowledge the following for their contribution to the ethics case study project in which without their help would not have been as successful.

- Teachers: William Trent of Monticello High School, and Alexis Mason of Charlottesville High School
- Mentors: Daniel Sparks and Rick White of 100 Black Men of Central Virginia and Chad Ratcliff of M-Cubed

UVA - President & Provost's Fund for Institutionally Related Research to Garrick Louis.

This work was supported by the National Science Foundation 568 under Grant # 1827820.

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