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# Developing a Strategy to Include Financially Disadvantaged Undergraduate Students into Graduate Engineering Programs

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# Developing a Strategy to Include Financially Disadvantaged Undergraduate Students into Graduate Engineering Programs


## Abstract

Longitudinal analysis of nationwide single and multi-institutional data shows the positive relationship between student educational outcomes and a diverse student population. Various position papers and empirical studies have raised awareness about the importance of diversity in higher education within the academic community and policy makers over the past half century. However, lack of participation by underrepresented students in higher education remains a chronic and multidimensional problem. Mitigating any particular factor and expecting broad based impact has not worked and will not work. The U.S. Department of education suggested some proven, over-arching principles for institutions of higher education to increase diversity, viz.: institutional commitment, diversity at all levels, outreach and recruitment, support services for students, and an inclusive campus environment. While some of these principles can only be addressed at the institutional level, a department or college can adopt scaled versions of these principles and influence the policies at the institutional level. This paper discusses the journey of a school of engineering towards developing strategies for improving equity, inclusion, and diversity in the graduate programs in engineering. In the process, this group of researchers articulated some critical issues that prevent diverse and economically disadvantaged undergraduate students from seeking a graduate degree in engineering. The authors have identified the following major reasons hindering students from pursuing a graduate degree: lack of financial support and resources, fear of the unknown, imposter syndrome, and family pressure to start earning as soon as possible. Each of these areas requires a targeted approach to help diversify the graduate engineering programs. A GVSU team comprised of administrators and faculty members sought to build a comprehensive program that incorporates all of the aforementioned structures and others. This paper describes the development strategy of such a program that culminated with an NSF (National Science Foundation) award.


## Introduction

The impact of diversity on students' educational outcomes in higher education is well documented and supported by numerous analyses. Longitudinal analysis of nationwide single and multi-institutional data shows the positive relationship between learning outcomes and a diverse student population. One of the most influential studies was done by Gurin et al. [1] where student survey data was reviewed from two longitudinal databases: Michigan Student Survey (MSS) and Cooperative Institutional Research Program (CIRP). The MSS dataset consisted of 1,582 students who were admitted to the University of Michigan in 1990, and the CIRP dataset contained 11,383 students who entered college in 1985 from a total of 184 four-year institutions. According to them, educational outcomes can be categorized as learning outcomes and democracy outcomes. Learning outcomes include active thinking, intellectual engagement and motivation, and academic skills, while democracy outcomes include citizenship engagement, compatibility of difference and democracy, perspective-taking, and racial/cultural engagement.

Through their study, they found that both their single institutional and national datasets indicated that diversity positively influenced both educational outcomes.

While diversity does appear to positively influence educational outcomes, Allport [2] states that simply attending a diverse institute of higher education is insufficient. This is what has been termed as structural diversity which is simply the number of students from various backgrounds. Instead, the quality of interaction is of importance. While structural diversity does increase the probability of a student encountering other students with diverse backgrounds, it does not guarantee a high-quality interaction. Gurin et al. [1] discuss two other forms of diversity: informal interaction diversity and classroom diversity. The former involves interaction with diverse students outside of the classroom, and this is where most meaningful interaction happens, while the latter involves learning about diverse people and interacting with such peers in the classroom. Informal interaction diversity and classroom diversity generate the impact on educational outcomes, but structural diversity is required for the other two to exist.

Piaget [3] states that encountering diverse students results in differing perspectives and equality in relationships, and both are of critical importance for a heterogeneous society to function effectively. Gottfredson et al. [4] in their study examined data from two separate samples to study the effect of diversity on student outcomes. One sample contained data from 1,963 volunteer law students from 16 law schools while the second sample was more nationally representative and contained data from 6,100 students from 50 law schools. Both datasets found a positive correlation between diversity and educational outcomes and concluded that institutions must promote and support informal interactions between students of diverse backgrounds; this conclusion aligns with that from Gurin et al. [1]. Chang [5] attempted to determine a link between diversity and educational outcomes purely based on empirical data from various sources. The conclusion was that campus diversity does in fact have direct and indirect positive effects on student learning experiences, and the critics who argue otherwise are incorrect. Hurtado [6] examined data from 16,000 faculty across 159 predominantly white institutes from a survey that was administered by the Higher Educational Research Institute. Student responses from the renowned CIRP survey were also examined to understand the link between student diversity and educational outcomes. From this empirical study, Hurtado concluded that diversity in the student population is necessary to improve civic (cultural awareness, acceptance of multiethnic people, tolerance of different beliefs, and leadership ability) and learning (critical thinking and problem-solving) outcomes. Improving both these outcomes results in a diverse workforce that is required for the growth and sustainability of the American society. Several other researchers also posit that a diverse student body enriches the environment thereby enhancing the learning experience of these students and their peers to bolster America's economic competitiveness [7-10].

As is evident, various position papers and empirical studies have raised awareness about the importance of diversity in higher education within the academic community and policy makers over the past half century. However, lack of participation by underrepresented students in higher education remains a chronic and multidimensional problem [11]. In our paper, we define underrepresented students as those who represent ethnic minorities, females (in STEM only),

persons with disabilities, first generation, rural, veterans, and all low-income students; this is consistent with the guidelines from the National Science Foundation (NSF). In the decade between 1993 and 2003, college enrollment of certain minority students (African American, Native American, and Hispanics) rose by 42.7%, 38.7%, and 68.8%, respectively. While this shows growth in the right direction, when it comes to undergraduate STEM fields and graduate school, these groups are poorly represented. With respect to gender diversity, while more women are earning college degrees, their representation in STEM fields remains low. For example, at the State University of New York (SUNY), a total of 2,737 students enrolled in the Fall 2017 semester with 52% being females and 48% males. However, of the 528 students that enrolled in the school of engineering technology, only 8.5% of them were females while only 6% of these 528 students classify as underrepresented [11]. The U.S Department of Education [12] recently identified that only 11% of students who identify as low-income (includes all ethnic groups) earn an undergraduate degree within six years. This is a remarkably low number given that 58% of students from the highest income group earn an undergraduate degree within the same timeframe.

Another concerning issue running parallel to the low enrollment in STEM fields is the high attrition rate. A 2013 report from the Department of Education [13] shows that approximately 48% of students pursuing their bachelor's degree in STEM fields eventually leave without completing their degree. Research also shows that minority and low-income students have a higher attrition rate in STEM fields when compared to their counterparts [13,14]. These numbers are not promising in the graduate schools as well. The estimated average attrition rate in the graduate schools in the United States is a staggering 50% [15], while only 41% of STEM students graduate within the first two years of enrolling in a Master's program [16]. The high attrition coupled with the already low enrollment is a major concern. Data shows that minority students make up a small percentage (less than 25%) of the graduate student population nationwide [17]. The U.S Department of Education states that in 2015-2016, only 13.7% African American and 9.7% Hispanic students were conferred master's degrees in engineering compared to 66.5% White students [18]. Furthermore, the participation of low-income students in the graduate school is low as well, and strategies to improve diversity need to be developed and implemented [19,20].

Brown-Glaude [21] states "*solving these deep-rooted inequities requires multiple strategies including affirmative action policies and diversity programs*." It is evident that mitigating any particular factor and expecting broad based impact has not worked and will not work. The U.S. Department of education, in a key 2016 report, suggested some proven, over-arching principles for institutions of higher education to increase diversity, viz.: institutional commitment, diversity at all levels, outreach and recruitment, support services for students, and an inclusive campus environment [22]. While some of these principles can only be addressed at the institutional level, a department or college can adopt scaled versions of these principles and influence the policies at the institutional level.

This paper discusses the journey of a school of engineering towards developing strategies for improving equity, inclusion, and diversity in the graduate programs in engineering. First, we

look at the institution's history of commitment and diversity efforts followed by those at the college level. For the three principles: outreach and recruitment, support services, and inclusive environment, the authors investigated the existing barriers and ways to address them. In the process, this group of researchers articulated some critical issues that prevent diverse and economically disadvantaged undergraduate students from seeking a graduate degree in engineering. Realizing this, a Grand Valley State University (GVSU) team comprised of administrators and faculty members sought to build a comprehensive program that incorporates all of the aforementioned structures and others. This paper describes the development strategy of such a program that culminated with an NSF award.

## Development of Program Structure

It is understood that without institutional commitment to diversity and active efforts to diversify at all levels within the institute, it is impossible to recruit, retain, and graduate underrepresented students in an engineering graduate program. Though the authors of this proposal didn't impact those initiatives at the institutional level, it was imperative to study the commitment and progression of the university in order to develop sustainable program level structures. The following two subsections describe the institutional efforts and history towards diversification.

### *University Efforts*

GVSU is a masters comprehensive public university in Michigan state with a total enrollment of 24,033 students. The student body comprises of 21,204 undergraduates and 2,829 graduates. Of the undergraduate students, 82% are white, 5.9% are Hispanic, 4.2% are African Americans, and 0.3% are American Indian or Alaska Native. At the graduate level, these numbers are 80.6%, 3.2%, 3.5%, and 0.4%, respectively. In comparison, the statewide demographics are: 79.2% white, 5.3% Hispanic, and 14.1% African American. Efforts to focus on inclusion and equity at the university level have a long history. In the 1970's, the university established the Multicultural Center that supported a wide range of cultural activities as well as academic and support programming to the Minority Education Cohorts: Minority Science Education Cohort, Minority Teacher Education Cohort, and Minority Business Education Cohort. This was the primary approach at the university level which was thereafter complemented by department/college level efforts such as outreach via summer camps and privately funded scholarships. In 2008, GVSU created the Division of Inclusion and Equity and was one of the first universities to establish the Chief Diversity Officer position at a level reporting directly to the President. The Division of Inclusion and Equity conducted several climate studies to gather quantitative and qualitative information to understand student concerns as a result of on-campus bias incidents. It also supported the growth of numerous efforts such as People of Color Network, LGBT Faculty/Staff Association, and the Intercultural Awareness Committee. The goal was and has always been to establish a multifaceted and coordinated approach to promote inclusion and equity

In 2011, a university-wide Inclusion Implementation Plan (IIP) was completed which identified four key areas: Access and Equity, Campus Climate, Diversity in Curriculum/Co-Curriculum, and Organizational Learning. GVSU has been a leader in campus climate assessment and completed its fifth assessment in 2015. Data from this was used to drive strategic decisions in the

next phase. Moving forward, GVSU's commitment includes sustaining institutional efforts to ensure that equity is embedded across the campus, and ingrained in all functions, decision making, and planning [23]. The next phase focuses on the following three broad areas: Equity and structural diversity, Inclusion and campus climate, and Learning and development. In equity and structural diversity, the sub-areas are recruitment and retention of students, faculty and staff; nondiscrimination and compliance; affirmative action and equal employment opportunity; procurement/supplier diversity; and education pipeline and outreach. Inclusion and campus climate efforts focus on acquiring campus climate and diversity-related data to develop data-driven action plans. This includes climate assessment; education and response to bias; intergroup relations and discourse; institutional development; external relations; and alumni relations. The sixth climate survey is currently being administered, and data will be subsequently used for decision making. Learning and development focuses on curriculum and instruction; research and inquiry; leadership development; and social justice to aid in advancement of inclusion and equity.

The Division and Inclusion and Equity has conducted several initiatives in collaboration with students, faculty/staff, and community partners. Table 1 highlights these initiatives and intended goals.

*Table 1: Developed initiatives and associated goals*

| Initiative | Goal |
|---|---|
| Faculty/Staff affinity groups | Engage in mentoring and to foster community among diverse faculty, staff, and student populations |
| Campus climate surveys | Aid in data-driven decisions to improve diversity |
| Inclusion advocate program | Aid in affirmative action and equal employment opportunity |
| Intersectionality | Encourage faculty/staff and students to view the world through multiple dimensions |
| KCP future faculty | Increase pool of underrepresented candidates pursuing faculty teaching careers |
| Faculty development and diversity | Provide faculty with resources to support inclusive learning environment |

In recognition of these efforts, GVSU was one of only three universities to receive both the Seal of Excelencia and ASEE Deans Program Award. In addition, GVSU is a Higher Education Excellence in Diversity (HEED) recipient, Michigan Minority Supplier Development Council's Corporate ONE award recipient, and was also named as a Role Model Institution by Minority Access Inc.

*College Efforts*

The Padnos College of Engineering and Computing (PCEC) has about 2,200 undergraduate and graduate students, of which 35% are first generation students and 30% are Pell-eligible. Furthermore, at the undergraduate level, 16.6% are females, 3.7% are African American, 4.7% are Hispanic, and 0.4% are American Indian or Alaska Native. In the graduate school, the corresponding numbers are 26.1% female, 4.3% African American, and 3.4% Hispanic. The PCEC has been engaged in several activities over the years to improve diversity in all levels.

The Science Technology & Engineering Preview Summer (STEPS) camp for girls was developed as an intervention strategy to address the growing concern of middle school girls abandoning STEM curriculums in school. This day-camp focuses on girls entering the 7$^{th}$ grade and aims to increase the quality, diversity, and number of students prepared to major in engineering and computing. Close to 1,500 campers have completed this program, 27% of whom are from underrepresented groups. To enhance diversity at the undergraduate level in STEM (ethnic minority, females, and low-income students), PCEC secured a STEM grant from the NSF. The goal of this RISE (Retaining and Inspiring Students in Science and Engineering) program is to address the lack of diversity in STEM fields and also to improve retention and graduation rates through disciplinary socialization. It provides a set of four-year progressively increasing scholarships to low-income, academically talented undergraduate students while also immersing scholars in cohorts to provide a robust support network. This grant was developed based on data generated from three other NSF STEM grants secured by GVSU at the undergraduate level.

Another key effort is targeting inner city and other high schools with a diverse student population. These connections create a pipeline for students to pursue STEM majors. Following the use of data analytics, a Student Success Center was established where faculty help students succeed in specific courses thus reducing attrition in first and second year. To help with retention and diversity among faculty, flexible work schedules and family-friendly policies and practices have been implemented. The more the work/life balance opportunities, the greater the benefits are in recruitment, productivity, retention, satisfaction, and decrease in unscheduled absences. With respect to gender diversity, GVSU exceeds the national average employment numbers. Based on these extensive efforts, the PCEC has been recognized by the American Society of Engineering Education (ASEE) for its effort in diversity. The PCEC received the bronze-level award from the ASEE's Diversity Recognition Program; this was the highest award at that time.

GVSU and the PCEC have been focused on improving diversity over the years. The university is predominantly white with a large number of students being Pell-eligible and first generation. The surrounding area is also predominantly white and, therefore, significant increase in diversity with respect to ethnicity cannot be expected. However, diversity can be improved by focusing efforts on first generation students, women in STEM fields, and low-income, academically talented students. While there have been efforts at the undergraduate level to improve diversity, unfortunately the same cannot be said at the graduate level, especially in engineering. At our university, only 8.3% of graduate engineering students identify as low-income. It is clear that a vicious loop exists where low income prevents potential students from pursuing graduate

education and essentially securing greater career and earning potential. Data shows that students from low-income families do not pursue graduate education when compared to students from families with higher income [24]. Furthermore, at our institution, the gender diversity in the Master of Science in Engineering (MSE) program is low with only 15% of the students being female. The next section discusses the barriers that prevent diverse and economically disadvantaged undergraduate students from seeking a graduate degree in engineering.

*Identifying Barriers to Graduate Education*

As mentioned previously, the average attrition rate in graduate schools in the United States is around 50%, and only 41% of STEM students graduate within the first two years of starting their Master's degree. While these statistics clearly indicate that participation of marginalized students and attrition rate in the graduate school need to be improved, it is crucial to understand the underlying factors that drive these concerning statistics. Addressing these factors will improve diversity and success rates in the graduate schools thereby resulting in an educated, well-trained workforce which is critical in driving innovation and competition in the global economy. Utilizing evidence-based literature and evaluation of anecdotal local situations, the authors have identified the following major reasons preventing students from pursuing a graduate degree: lack of financial support and resources, fear of the unknown, imposter syndrome, and family pressure to start earning as soon as possible. Each of these areas requires a targeted approach to alleviate these barriers and consequently improve the existing situation.

*Financial Support and Resources:* Evidence-based literature has shown financial support via scholarships and grants positively influences retention of low-income students [25]. Kniffin [26] and Nevill and Chen [27] have shown that disadvantaged students have a higher tendency to drop out of graduate programs. Also, dependent students from lower income families are less likely to complete their graduate degree when compared to dependent students from higher income families [28]. According to the U.S. Department of Education [29], students from higher income families are more likely to enroll in graduate school. The education level in students' immediate social circle also plays a major role in their pursuit of graduate education; this is the same phenomenon as high school students opting for college or not [30]. Apart from economic barriers, first-generation students are also less likely to be aware of the graduate school application procedure and funding opportunities. Mullen et al. [31] have shown that 76% of first-generation students do not proceed to obtain a Master's degree. The U.S Department of Education is deeply concerned about low rates of participation from such students due to the increasing demand of graduate degreed professionals for the success of the economy [32]. Low-income students make up only 8.3% of the graduate student population in our MSE program at GVSU, and this number must be improved. Improvements can be addressed through financial support via scholarships and dedicated program-level resources such as advisors/mentors and other high-impact structures. Though financial challenge can be a barrier, Barry and Mathies [33] have shown that it is not the only key factor when it comes to graduate student retention. Evidence suggests that successful completion of a Master's degree strongly depends on motivation and program-level resources such as advisors and program structure [34].

*Imposter Syndrome:* Imposter syndrome occurs when individuals doubt their worthiness and competency and attribute their success to sheer luck or fraudulence. This affects high achieving students as well and acts as a barrier to their pursuit of a Master's degree [35]. Students feel that they are not worthy and doubt their competency, which in turn results in low self-efficacy [36]. The chance of succeeding at a given task, for example successful completion of a graduate degree, scales with self-efficacy due to increased persistence. Thus, increasing the self-efficacy of a student will have a positive effect on graduation rate [37,38]. Vicarious experiences and verbal persuasion via direct faculty mentoring [39] can help to improve self-efficacy. Pairing low-income, academically talented students with a faculty mentor generates positive outcomes for graduate school preparation [40]. High attrition rates in graduate schools necessitates sustained mentoring at various levels [41,42], and mentoring has shown to improve retention, increase self-efficacy for students, and contribute to the development of both mentor and mentee [43, 44]. It has been shown that faculty mentors also demonstrate increased productivity [45, 46] and these faculty members become a permanent asset to the institution. Furthermore, peer mentoring has been shown to improve one's self-worth and oral presentation skills which in turn helps address the imposter syndrome [39, 47]. At GVSU, all undergraduate engineering students are required to complete three alternating semesters of cooperative (co-op) experiential learning in the industry where each student eventually gains a year of full-time, paid industry experience. Through employer/student surveys and speaking with these students about their co-op, we have found they become more self-confident over time, improve their network, and gain valuable hands-on experience.

*Fear of Unknown:* Many students also fear the thought of pursuing a graduate degree due to fear of the 'unknown'. Unknown factors include the level of academic difficulty, their ability to cope with stress, a fear of rejection, a fear of losing their undergraduate friend circle, and an inability to balance academic life with personal life [48]. This barrier can be alleviated through faculty and peer mentoring, cohort immersion, and targeted seminars which help students be more aware of their opportunities and responsibilities in graduate school. Seminars have also been shown to improve retention and academic achievement. A graduate seminar series for dual BS/MS engineering students was shown to be helpful in making the students aware of the increasing challenges and responsibilities at the graduate level while simultaneously enhancing their soft skills [49]. Various studies have shown that immersing students in a cohort is very effective in addressing some of the said barriers [50, 51]. When placed in a cohort, these students travel together throughout their academic journey resulting in long-lasting friendships and improved network which helps address the fear of unknown. Furthermore, they also help one another during their graduate tenure thereby improving their communication skills and self-confidence.

*Family Pressure:* Finally, pressure from the students' families to begin earning an income as soon as possible is another major contributing factor; the additional financial and time commitment can be hard to justify to their families. Consequently, many academically-talented students shy away from obtaining their Master's degree, resulting in national shortages in the STEM workforce and diminished global economic competitiveness [52]. It is widely recognized that STEM professionals are pillars to the national economy for wealth and prosperity [52, 53], and an educated, well-trained workforce is essential to drive innovation and compete in the

global economy [54]. This area can be improved upon by developing a curriculum to help the student complete both the BSE (Bachelor of Science in Engineering) and MSE degrees in a compressed timeline. This accelerated route allows students to graduate with both degrees and enter the workforce earlier while minimizing cost and maximizing career earnings. This is achieved via a combined degree program which is an articulation of undergraduate and graduate curriculum to shorten the time and cost to complete both degrees. Literature has shown that articulation between two different academic levels has propelled more students to achieve the advanced degree who otherwise would have not pursued it. The NSF's Advanced Technical Education Program has documented success of articulation between associated and baccalaureate degrees in the STEM field [55].

*Infrastructure to Address Barriers*

The researchers were convinced about institutional commitment and support at the university and college level as described in the previous sections. However, it was evident that additional support for individuals are needed to recruit, retain and graduate underrepresented students in the engineering graduate program.

Drawing from the evidence-based practices, the authors proposed an infrastructure to recruit, retain, and graduate low-income, academically-talented graduate engineering students that was highly rated by the NSF panel and subsequently approved for funding. The program is mostly available for GVSU's undergraduate students but can be available to students who transfer from other institutes during their sophomore year. The infrastructure leverages existing support structures from the GVSU school of engineering while developing new ones as well. Figure 1 highlights the proposed framework where the four main target areas are: Shortening Overall Time Frame; Financial Support; Socio-Cultural Support; and Academic and Career Support. A brief description of each area is provided below.

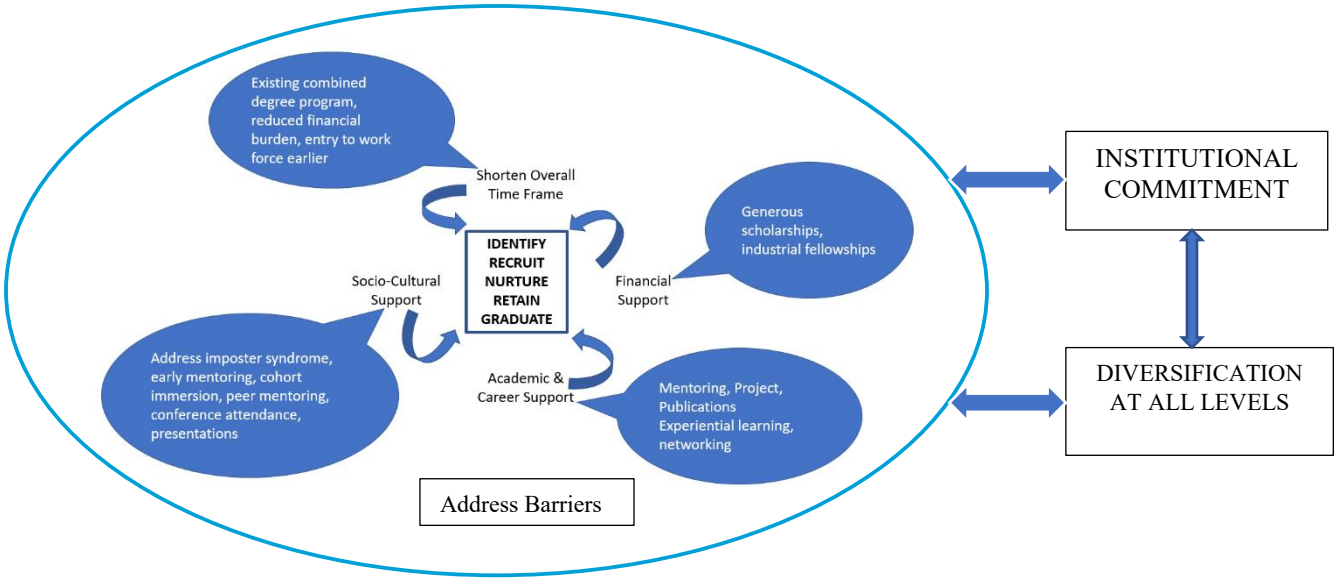


*Figure 1: Key elements to address issues identified in literature*

Shortening Overall Time Frame:

First, we make use of the existing combined degree program which allows for students to earn both the BSE and MSE degrees with just one additional year, whereas a traditional MSE degree takes usually two or more years to complete after the BSE. The combined degree program allows academically talented (high GPA) undergraduate students replace two of their three required undergraduate electives with graduate courses while also replacing their industry sponsored senior design project (capstone) with their Master's thesis/project. With this, they are able to replace up to 11 undergraduate credits with graduate credits thereby accelerating their graduate degree while also reducing cost. The compressed timeline allows the scholars enter the workforce a year earlier thereby maximizing their earning potential. This structure helps address the family pressure barrier.

Financial Support:

Each scholar receives a generous scholarship from the NSF project which significantly eases the financial burden. A maximum of $20,000 is awarded per student over the final two years of their academic tenure, i.e. undergraduate senior/graduate first year and graduate second year. In addition, the industry-sponsored graduate fellowship (IGF) is a paid experience which further defrays their educational cost. For those students who still require financial assistance, a half graduate assistant (GA) position at the school of engineering that waives 4.5 credits of tuition per semester along with a semester stipend of $2,000 will be available. In addition to reducing financial burden, proposed IGF and GA activities will help to reduce imposter syndrome and to develop professional skills.

Socio-Cultural Support:

From the literature, mentoring appears to solve multiple areas such as access to resources and reducing imposter syndrome and fear of the unknown. Therefore, mentoring forms the backbone of this program structure. However, the nuance in the proposed structure is early intervention via mentoring. Potential candidates are identified as early as their sophomore year, and selected scholars are partnered with a dedicated faculty member to commence the mentoring process early. The faculty mentors provide the support and inspiration to orient their mentees toward graduate education. Peer mentoring is also utilized where each scholar is partnered with a current senior graduate student. The graduate student will then share his/her experience with the scholar and educate them about the rigor, work habits, and potential gain of graduate education. When the scholar is in his/her final graduate year, they then mentor their juniors which in turn helps with imposter syndrome. Each recruited scholar will be part of a cohort of approximately six students. They will travel with their cohort from the sophomore year of their undergraduate degree all the way till they graduate with their master's degree. The authors have also planned several activities, such as design and build projects, formal interaction with professionals at various levels, shadowing of industrial leaders, to promote cohort bonding and various other networking opportunities. Through their group projects, the scholars will work on hands-on projects and will travel as a group to a conference to present their design. This will help improve their technical ability, self-worth and communication skills. Throughout their academic tenure,

targeted seminars are conducted to inform them of best practices and educate them on the graduate school requirements and available internal scholarship opportunities. Together, these structures address the fear of the unknown and imposter syndrome barriers.

Academic and Career Support:

Each cohort works on identifying an existing problem that is worth solving, developing concept solutions, and designing and building a prototype solution within budgetary and other constraints. Among the current recruits, one cohort is working on developing a novel initiative to help motivate the younger generation to participate more in recycling to create a sustainable environment, while another cohort is working on a device that harvests waste energy. Eventually, each cohort will have to write a technical paper and present their designs at various conferences where they travel as a group and get to network with students and professionals from around the globe. This will improve their self-worth and aid in reducing the imposter syndrome. The program will also leverage the existing ties that GVSU has with local industries and require each scholar to do an industry-sponsored graduate fellowship. This is a paid opportunity that gives them valuable experience while also providing much needed financial support. At any stage in their academic tenure, the scholars receive continuous academic and career support through their mentors. The relationship between the mentor and mentee is a lifelong one that immensely benefits the scholars. The mentors will serve as a reference for employment or Ph.D. recommendation and aid the scholar in shaping their future goals. The imposter syndrome and lack of resources barriers are addressed via the aforementioned activities.

## Conclusion

Lack of participation by underrepresented students in higher education remains a chronic and multidimensional problem that requires addressing multiple areas such as institutional commitment, diversity at all levels, outreach and recruitment, support services for students, and an inclusive campus environment. While investigating barriers that prevent underrepresented students from pursuing graduate education, the authors identified the following four major reasons: lack of financial support and resources, fear of the unknown, imposter syndrome, and family pressure to start earning as soon as possible. Each of these areas requires a targeted approach to help diversify the graduate engineering programs. After analyzing each area, a comprehensive program structure is developed that addresses the aforementioned issues.

Based on the above program structure, NSF grant DUE# 2030615 was approved, and the grant is currently in its early stage of execution. Four months since the grant officially commenced, 15 academically-talented, low-income students have been recruited into the combined degree program. These students are participating in various formal activities in the proposed program. Of these 15 students, six students are about to complete their junior year. They have already applied and been accepted to the graduate program and will start their formal graduate education in the winter semester of 2022. The remaining seven students are in their sophomore year, and we are currently mentoring them to better orient them towards graduate school. They will commence their application process in the summer of 2022. Though anecdotal evidence suggests enthusiasm in newly recruited students, a formal study is will be conducted to assess the effects

of the various components of the structure on recruiting, retaining, graduating, and launching them to successful careers. The assessment will explore the effect of the high-impact activities on psychological variables including imposter syndrome and self-efficacy. Though some early assessment is done, it will require observation and data collection for multiple cohorts to draw scientific conclusions. The authors hope to present the results of those assessment in future publications.

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