Supporting Student Success in Engineering by Promoting the Participation of Underrepresented Minorities in Research Venues

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In this study, the recruitment model termed Identify, Build, Integrate, Evaluate, and Extend (IBIEE) was implemented to attract, advance, and advocate the participation of underrepresented engineering students to a research collaboration effort between The University of Texas Rio Grande Valley (UTRGV) and a National Laboratory. The purpose of the partnership between these two entities is to meet the following goals: a) find innovative manufacturing techniques for weapons development, and b) prepare UTRGV students to conduct internships and be employed with the National Laboratory. Similarly, the internal aim of UTRGV is to 1) support student success in engineering by promoting the participation of underrepresented minorities in research venues and foster academic inclusion, development, and mentorship; and 2) increase the number of underrepresented students hired in the engineering workforce. The recruitment process began in the Spring 2024 semester incorporating the IBIEE model, which was centered on nurturing a disposition from the project Principal Investigator (PI) and Co-Principal Investigator's (Co-PI's) to proactively identify and recruit engineering students into the research collaboration effort. Such recruitment process included five major components: 1) identify students in the classroom setting, 2) build relationships, 3) inquire about short and long-term academic interest, 4) evaluate academic interest, and 5) extend invitation to participate. To this end, a total of eleven underrepresented students from different engineering disciplines have been hired to participate in the project; three graduate students and eight undergraduate students. The mentorship model termed Relationship, Commitment, Desire, and Disseminate (RCDD) is being simultaneously adopted to promote engineering student success through a genuine mentorship role and prepare students for graduate school and post-graduation employment.

I. BACKGROUND AND MOTIVATION

Research Venues

According to numerous studies, it is well-established that student participation in research venues and proper faculty-student mentorship are two commonly implemented methods that promote and enhance student success in higher education. A significant number of undergraduate students pursuing Science, Technology, Engineering, and Mathematics (STEM) related fields engage in research opportunities. Particularly, these research opportunities have immediate and long-term benefits [1], [2], [3]. According to studies conducted by Russell, 53% of undergraduate students pursing STEM related careers are involved in some form of research activity before matriculation [4], [5]. In this regard, studies reveal that participating in such venues is beneficial towards developing technical, communication, and leadership skills [3], [6]. In a study conducted by the National Science Foundation (NSF), 88% of its respondents, which held undergraduate research positions, reported significant development in structuring a research project, 83% of its respondents expressed greater confidence in research and professional abilities, and 73% attested awareness of a graduate school environment [6], [7], [8]. [9]. According to Hurtado *et al*. [1], being involved in research venues has further facilitated the decision of its participants to pursue STEM careers and advanced degrees post-graduation [3].

Despite the immediate and long-term benefits of undergraduate research, it is well-documented that the number of underrepresented minorities participating in such venues is relatively low

compared to other ethnic groups. As such, federal and private agencies have invested in structuring academic and mentorship programs to attract underrepresented students to such enhancing opportunities [9], [10], [11]. The Minorities Opportunities in Research (MOR) program, for instance, was structured to provide underrepresented students an opportunity to develop their academic and personal skills through professional development sessions, assigned mentors, and tuition assistance. Further, Lopatto and Gasiewski *et al.* demonstrated that underrepresented minorities participating in undergraduate research venues build stronger connections amongst their peers [7], [12].

Mentorship

Studies further suggest that proper faculty-student mentorship is required for student success. Chavous *et al.* from the University of Michigan specifically reported that underrepresented minorities have a strong inclination towards finding a same-race mentor since it promotes a stronger sense of belonging and a higher academic efficacy [3]. Research additionally attests that people who possess the same ethnic background have exceptional communication, understand each other better, and eliminate cultural hardships during matriculation [3]. In higher education, according to Gordon, mentorship roles are critical given that approximately twenty to fifty percent of entering freshmen remain undecided about their major, while seventy-five percent change their major at least once prior to matriculating [16]. Faculty mentorship is additionally indispensable as undergraduates will eventually transition into professional roles post-graduation.

In this regard, a mentorship role can exert a greater influence on student success due to the relationship it builds between the protégé and faculty member [15]. In such studies, Levinson further describes the mentorship role as the most important relationship of young adulthood [15]. This type of influence can expose undergraduate students to comprehensive information such as internship opportunities, employment resources, graduate school, curriculum alternatives, undergraduate research venues, and professional experiences that may result favorable in future career aspirations.

Areas of Improvement

Not only are underrepresented students trailing other ethnic groups in terms of conducting undergraduate research, but studies also demonstrate that the number of underrepresented minorities pursuing graduate school, employed in STEM fields, and employed in higher education are relatively low [1]. Minority groups such as African American (3.8%), Latino (4.1%), and Native American (0.4%) constitute a relatively small percentage of underrepresented communities pursuing graduate school in STEM disciplines [10]. Similarly, according to Funk and Parker, the Black community comprises 9% of all STEM workers, while 7% of the total STEM population is represented by the Hispanic community [13].

These startling numbers, in the context of undergraduate research opportunities, demonstrate that the number of underrepresented minorities conducting research might be even lower than those pursuing advanced degrees [13]. Hurtado *et al.* and Allen further imply that such gap may further be attributed to cultural and academic isolation, low expectations, and negative stereotypes in their surrounding undergraduate environment [1], [10]. Furthermore, according to the U.S. Department of Education, faculty from African American, Hispanic, and Native American heritage hold the lowest percentages amongst the faculty ranks [14]. 6.3%, 5.6%, and 3.6% of African Americans hold Assistant Professor, Associate Professor, and Full Professor ranks, respectively, while

Hispanics hold 4.3%, 3.9%, and 2.9% of the corresponding faculty ranks, and 0.4%, 0.4%, and 0.3% of Native Americans occupy the equivalent positions [14].

II. PURPOSE OF RESEARCH

Recruiting Model and Process

Given these well-documented facts, the objective of this study is to implement the recruitment model Identify, Build, Integrate, Evaluate, and Extend (IBIEE) developed by Marquez and Garcia in 2019 to attract, advance, and advocate the participation of underrepresented engineering students to a paid research collaboration effort between engineering faculty members of The University of Texas Rio Grande Valley (UTRGV), a minority-serving institution, and a National Laboratory [18]. The purpose of the partnership between these two entities is to meet the following goals: a) find innovative manufacturing techniques for weapons development, and b) prepare UTRGV students to conduct internships and be employed with the National Laboratory. Further, the internal aim of the UTRGV engineering faculty is to 1) foster academic inclusion, development, and mentorship within the research group; and 2) address the issue with retention rates at UTRGV.

In this regard, according to the retention rates from Texas Public Universities, UTRGV has an average freshman retention rate of 75% (Table 1) [19], [20]. This data is relatively low compared to institutions across the state of Texas such as Texas A&M University (92%), UT Dallas (88%), UT Austin (95%), and Texas Tech (85%) but higher than many other institutions.

Table 1. Texas Public Universities Freshman Retention Rates. Freshman entering in Fall 2015 through Fall 2018 (usnews.com/best-colleges/rankings) [20]

Texas Public University	**Average Freshman Retention Rate**
UT Austin	95%
Texas A&M University	92%
UT Dallas	88%
University of Houston	85%
Texas Tech University	85%
University of North Texas	79%
Texas State University	77%
Texas Woman's University	76%
Sam Houston State University	76%
UT Rio Grande Valley	*75%*
UT El Paso	74%
UT San Antonio	73%
UT Arlington	72%
Texas A&M Kingsville	68%
Texas A&M Commerce	66%
UT Tyler	64%
Texas A&M Corpus Christy	58%
Texas Southern University	54%

Statistical data further indicates that retention rates of first year (full-time) students in the College of Engineering and Computer Science have been at an average of 60% between the Fall of 2015 and Fall 2019 (Table 2) [19], [20]. However, it was observed that such trends declined in the wake of COVID-19. Retention rates of incoming students, for instance, declined to 53.3% in the Fall 2021, while retention rates within the institution similarly plunged to 60.9%.

Table 2. UTRGV College of Engineering and Computer Science First Year Full Time Freshman 1st Year Retention Rate [20]

Cohort	Retention Within College	Retention Within University
Fall 2015	62.3%	78.2%
Fall 2016	66.6%	77.0%
Fall 2017	64.7%	74.9%
Fall 2018	69.4%	78.5%
Fall 2019	67.2%	79.0%
Fall 2020	53.3%	60.9%

To this end, the recruitment process began in the Spring 2024 semester incorporating the IBIEE model, which was centered on nurturing a disposition from the project Principal Investigator (PI) and Co-Principal Investigator's (Co-PI's) to proactively identify and recruit engineering students into the research collaboration effort. According to the IBIEE model, this recruiting strategy represents an alternative and practical solution to the current norm in which undergraduate students serve as the primary agent in finding research opportunities [18]. Instead, faculty members play a pivotal role in engaging, motivating, and supporting the growth and development of underrepresented students, which was the case for the collaboration between UTRGV and the National Laboratory. Such recruitment process included five major components: 1) identify students in the classroom setting, 2) build relationships, 3) inquire about short and long-term academic interest, 4) evaluate academic interest, and 5) extend invitation to participate.

Mentorship Model Adopted

The UTRGV engineering faculty members participating in the research collaboration decided to enhance the student academic experience by further adopting a mentoring role within the research group. In this case, the mentorship model Relationship, Commitment, Desire, and Disseminate (RCDD) developed by Marquez and Garcia in 2021 is being simultaneously adopted to promote engineering student success through a genuine mentorship role and prepare students for internship opportunities, graduate school, and post-graduation employment [17].

The adopted model identifies four key elements of the transformative process: 1) develop student-faculty relationship; 2) faculty commitment; 3) genuine desire for the mentee to succeed, and 4) willingness from faculty members to disseminate appropriate wisdom [17].

III. METHODS AND ANALYSIS

In this study, the IBIEE model and the RCDD model were implemented to 1) recruit students from UTRGV to conduct research with the National Laboratory and 2) to provide mentorship. The authors utilized a self-developed, small survey instrument, which was electronically administered to the hired UTRGV students, to inquire into the effectivity of the recommended models.

As such, this research draws from a social constructivist theory that is based on the belief that all knowledge is socially constructed and mediated by historical and cultural factors [21]. Contemporary views and practical applications of social constructivism is a learning theory and pedagogical approach of psychologist Lev Vygotsky [22]. According to Vygotsky, "Education is realized through the students' own experience, which is wholly determined by the environment and the role of the teacher then reduces to directing and guiding the environment (p.50)." This theoretical position indicates that the instructor has a significant influence in shaping the learning experiences of learners and serves as a critical role to foster the intellectual and cognitive development of students.

To this end, a total of twelve (all Hispanic) underrepresented students from different engineering disciplines have been hired to conduct research in the project between UTRGV and the National Laboratory; three graduate students (all male students) and nine undergraduate students (7 males and 2 females). Many students at UTRGV showed interest in the research position, but given the limit on the grant, only students with an adequate grade-point average (GPA) were offered a position. From the graduate students, two of them are in the Manufacturing Engineering Department, while the other is in the Statistics Department. In terms of the undergraduate students, three of them are in the Mechanical Engineering Department, four in the Manufacturing Engineering Department, and two in the Engineering Technology Department.

Descriptive statistics were employed for analysis and presentation of data results. The authors note the following limitations of the study: (a) small sample size; (b) self-developed survey instrument; (c) convenient sampling procedure. The administered survey consisted of the following thirteen questions:

Question 1. Did a faculty member from the research group go to your class and talk about the project?

Question 2. Were you encouraged to apply/join the research team?

Question 3. Did you attend the National Laboratory information booth at the career fair?

Question 4. How did you learn about the National Laboratory research project?

Question 5. How comfortable did you feel asking a faculty member about research opportunities?

Question 6. Who did you reach out to express interest in the National Laboratory project?

Question 7. Prior to receiving an invitation to participate in research or applying for the position, did you have a good relationship with any of the faculty members conducting research?

Question 8. At any point have you talked to a faculty advisor about post-graduation career venues?

Question 9. Once accepted into the research group, what type of mentorship have you received from the faculty?

Question 10. Once accepted into the research group, what type of mentorship have you received from the upperclassmen in the group?

Question 11. How often do you meet as a research team?

Question 12. At any point did you talk to the faculty about graduate school or internship opportunities?

Question 13. Briefly explain your overall experience with the research group

IV. RESULTS & DISSCUSSION

Recruitment Process

The first component of the IBIEE model is to identify students who would be willing to conduct research. For the recruiting process, two strategies were implemented: 1) class visits, and 2) career fair. For the first strategy, 57.1% of students hired to conduct research with the National Laboratory indicated that the PI of the project indeed visited their class during the Spring 2024 semester (Figure 1), while the rest mentioned that they were not exposed to the research opportunity via a class visit.

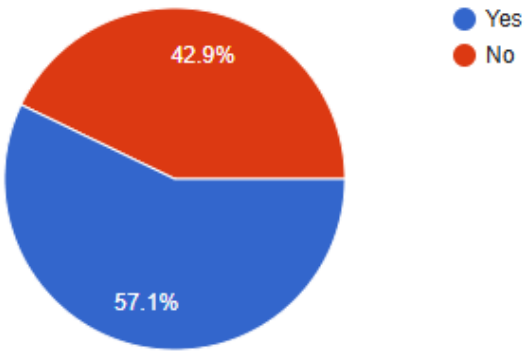

Figure 1. Strategy 1: Class visit

Students also mentioned that they had attended the career fair and that their experience was meaningful as related to the project. The following statements were shared:

"Yes, it was very informative in terms of available opportunities."

"Yes, they told me to send them an email and apply online."

"Yes, I spoke to the representative about which positions to apply for."

"Yes, since I met the National Laboratory scientists in the first review meeting, I just had a quick chat at the booth with them and give them my resume."

"Yes, it was a positive experience and they encouraged me to apply to their open positions."

In both recruiting strategies, students were encouraged to apply for a research position by engaging in conversation to eliminate intimidation barriers. This involved utilizing the second component of the IBIEE model. As such, the following statements were shared:

"Yes, the opportunity was presented during lecture. Students were encouraged to join with the possibility of working with/for the National Laboratory."

"Yes, I felt encouraged to apply as I learned the many opportunities that this research offered."

"Yes, the information they provided on the project seemed interesting which encouraged me to join."

Importance of Relationships

These statements demonstrate that UTRGV faculty members were adamant in building a strong relationship with students. In this regard, students were asked if they felt comfortable asking faculty members about research opportunities. Figure 2 indicates that 42.9% felt extremely comfortable inquiring about the research project, 42.9% felt comfortable, and 14.3% felt somewhat comfortable.

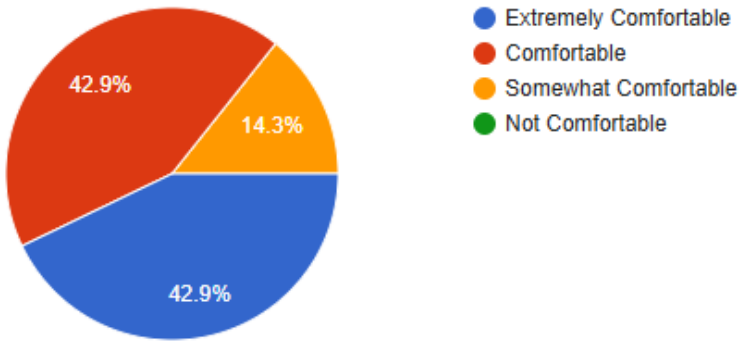

Figure 2. Inquiring about Research Opportunities

Students also mentioned that they had established a good relationship with faculty members prior to conducting research (Figure 3).

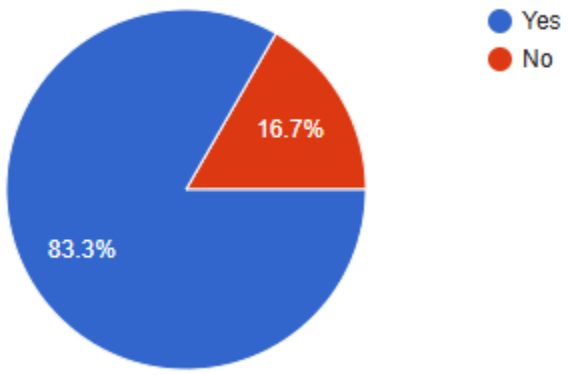

Figure 3. Good relationship with faculty members

Based on the results, 83.3% of the students mentioned that the faculty member established a consistent form of communication, which highlights the need of faculty to proactively develop meaningful relationships to support their academic development. These relationships represent a necessary component in the recruitment process as it promotes higher sense of belonging, trust, and higher levels of efficacy.

Mentorship Matters

Based on the open-ended response, students hired to conduct research with the National Laboratory shared information about attaining guidance related to graduate school, career options, and summer internships. The following statements were shared:

"I have talked with Dr. X about doing masters while also working summers or remote with LANL."

"Yes, we have spoken about career paths and the importance of having something secured prior to graduation."

"I talked with a faculty professor, and the experience was good."

"Both mentorship on the project itself and mentorship on how to proceed with possibly getting an internship at LANL or other companies."

"Mentoring on the importance of setting goals, thinking long-term, and leadership."

"The faculty have provided us with enough information to conduct research. They wish that we have an open mind for ideas and encourage us to ask questions, if need be."

These comments reveal the inclination of the faculty to provide mentorship to the students conducting research that will promote success post-graduation. Students additionally mentioned that they receive mentorship from the upperclassmen in their research group. The following statements were shared:

"Advise on getting a job after graduation and how their experience at LANL internships or other internships was."

"How to lead a group and the importance of working with a diverse group of people."

"Great mentorship, my upper classmates have helped me tremendously in conducting research."

Overall, students hired to conduct research have had a pleasant experience. Two of them have been hired to work for the National Laboratory after graduation, while others have been selected for a summer internship. The following statements were shared:

"Very valuable experiences and receive special opportunities."

"It has been great. I feel like I have developed both professionally and academically working at the group."

"It has been the opportunity of a lifetime and something I am extremely grateful for."

"I've made great connections with all the research groups so far. I've learned a great deal from conducting research and conversing with my coworkers and team leaders, and will continue to do so."

"Very positive and fun experience."

These comments reveal that faculty members play a pivotal role in engaging, motivating, and supporting the growth and development of underrepresented students.

V. CONCLUSION

A strong STEM workforce highly depends on creating policies, programs, and initiatives that provide equitable access and opportunities for all students, especially those from underrepresented and underserved communities. As such, the active recruitment and mentoring by faculty advisors is critical in engaging underrepresented students in research opportunities, which can have an impact on retention, persistence, and post-graduation outcomes such as pursuing graduate school and research-oriented opportunities.

Both the IBIEE and RCDD models were implemented to 1) recruit students from UTRGV to conduct research with the National Laboratory and 2) to provide mentorship. A total of twelve underrepresented students from different engineering disciplines have been hired to participate in the research project between UTRGV and the National Laboratory. To date, three UTRGV students from the summer 2024 research group have completed internships with the National

Laboratory and received full-time employment offers after graduation. Additionally, four other UTRGV students have received internship offers for the summer of 2025, and eight new students are being hired to join in Fall 2025.

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