

Campus Undergraduate Research Awareness and its Effect on Retention and Interest of STEM Majors

Mahmoud T. Khasawneh, Jared R. Dmello, Yahaira S. Franco, John C. Kilburn
Texas A&M International University
Laredo, TX 78041

Abstract

Despite efforts to increase interest and retention of STEM students to meet the demand for STEM professionals, science and engineering degrees account for only 35% of all bachelor's degrees in the nation. Minorities and women account for even smaller percentages of STEM degrees. Studies report that undergraduate research participation helps bridge the gap between classroom knowledge and real-world application for students. The objectives of this study are to discuss the impact of undergraduate research participation on STEM majors and to identify the factors deterring students from participating. Through undergraduate research, factors such as lack of mentoring, lack of self-efficacy, lack of academic preparation and stigmas associated with STEM fields may be addressed to provide a more diverse and inclusive environment for underrepresented minorities and women in STEM careers. This study employed survey methods to measure student awareness of undergraduate research opportunities at a mid-sized minority-serving regional institution. A total of 96 responses were collected and the survey administered included quantitative and open-ended qualitative questions regarding interests in research, participation in research, student college classification, and factors deterring interests or participation in research. Preliminary findings suggest that while 84% of students are interested in undergraduate research, only 18% participate in it. Participants cited lack of awareness of research opportunities and lack of knowledge on how to get involved as reasons for low research participation. Identifying the factors that keep STEM students from engaging in undergraduate research opportunities is important for the retention of STEM majors, especially for women and underrepresented minorities.

Keywords

Undergraduate Research, STEM Majors, Retention, Under-Represented Minorities, Engineering

1. Introduction

In our current economy, STEM (science, technology, engineering, and mathematics) careers are considered key components contributing to economic development and success of the United States in the global marketplace. Despite the efforts to increase the interest and retention of STEM students, science and engineering degrees account for approximately 35% of all bachelor's degrees in the nation [1]. The increasing demand for STEM majors has led to extensive programs and research to address the factors causing students to "leak" out of the STEM pipeline. Evidence has shown that undergraduate research experiences provide students with real-life applications of the knowledge they obtain in a classroom setting and helps them develop impactful mentoring relationships with faculty [2]. For many students, their mentors act as "door openers" as they provide knowledge on the academic culture, graduate school, and research opportunities [3]. Therefore, student participation and exposure to undergraduate research has been identified as a significant contributor to increased interest in STEM degrees [2, 4]. The purpose of this on-going study was to implement the first stage of the previously proposed survey-based framework to evaluate student awareness of and participation in undergraduate research at Texas A&M International University (TAMIU), a mid-sized regional university along the U.S.-Mexico border [5]. The implementation of this survey-based framework will allow us to identify the factors that deter students from engaging in undergraduate research at TAMIU. Finally, based on the survey findings we will propose recommendations to remediate student perceptions of undergraduate research in efforts to increase retention in STEM majors, bolster graduate degree attainment, and increase career prospects.

2. Methodology

To assess student involvement and awareness of STEM undergraduate research opportunities at TAMIU, the survey was implemented as presented in Khasawneh et al. (2020) survey-based framework. The 12-question survey was administered to students enrolled in STEM courses. Responses were collected between November 2019 and March 2020. In total, 96 responses were collected. The student survey collection instruments were approved by the University's Institutional Review Boards prior to release. Surveys included both quantitative and open-ended qualitative questions. Items included questions regarding student demographics, student interest in research and student participation in research. Percentages reported are the proportion of respondents who responded to the individual item, unless otherwise noted.

3. Findings

3.1. Sample Characteristics

Of the 96 respondents, 72.92% identified as males and 27.08% as females, which is inconsistent with the broader student population at the university. Per institutional student records, in Fall 2019, 61.3% identified as females and 38.7% identified as males. Although females constitute the majority of the institution's student population, there is a higher number of male engineering majors compared to females. The under-representation of females in STEM majors is in line with the national averages. Past research has found that males have an increased rate of interest and completion of undergraduate STEM degrees compared to females [6]. Respondents were distributed across student classification (e.g., freshman, sophomore, junior, and senior). The respondents primarily identified as seniors (51.04%) and juniors (33.33%). The respondents were also distributed across major, with the majority being Systems Engineering (66.67%) and Biology (12.50%), as seen in **Table 1**.

Table 1: Characteristics of the student respondents in the study

<i>Student Characteristics</i>		<i>(N)</i>	<i>(Valid %)</i>
<i>Gender</i>	Female	26	27.08
	Male	70	72.92
	Other	0	0.00
	Total	96	100.0
<i>Classification</i>	Freshman (0-29 hrs.)	4	4.17
	Sophomore (20-59 hrs.)	11	11.46
	Junior (60-89 hrs.)	32	33.33
	Senior (90+ hrs.)	49	51.04
	Total	96	100.00
<i>Major</i>	Systems Engineering	64	66.67
	Biology	12	12.50
	Mathematics	9	9.38
	Business Administration	3	3.13
	Pre-Engineering (Electrical)	1	1.04
	Communications	1	1.04
	Music	1	1.04
	Psychology	1	1.04
	Pre-Engineering (Mechanical)	1	1.04
	Multi-Disciplinary Studies	1	1.04
	No answer	2	2.08
Total		96	100.0

3.2 Student Interest in Undergraduate Research

In general, 84.38% of the students reported interest in undergraduate research and 15.63% reported no interest (**Figure 1a**). Previous studies have shown that research can provide important technical skills and experience needed to continue the pursuit of a STEM career (e.g., improve writing skills, knowledge of research equipment, mentoring relationships with STEM faculty and students) which likely contributes to student interest in research participation [3, 7, 8]. From the 15.63% respondents that reported no interest in undergraduate research (**Figure 1a**), 40.00% said it was due to lack of time for undergraduate research because of work or extracurricular activities (**Figure 1b**). Per institutional records, in Fall 2019, 56.8% of all undergraduates were low income and 54.9% of all undergraduates were first-generation college students. As reflected by institutional records, the economic background of the students may require them to work and study at the same time. While the factor of students balancing work and extracurricular activities is beyond the university's control, the institution does offer undergraduate research assistant job opportunities, when available. This helps students gain experience in their STEM field of study while maintaining a job.

The other reason deterring student interest in undergraduate research was unawareness of the opportunities in undergraduate research or how to get started in research (40.00%). Thus, highlighting a need to provide more support and disseminate information about undergraduate research to the STEM students. Lastly, 20.00% of the respondents reported no interest at all in research (Figure 1b).

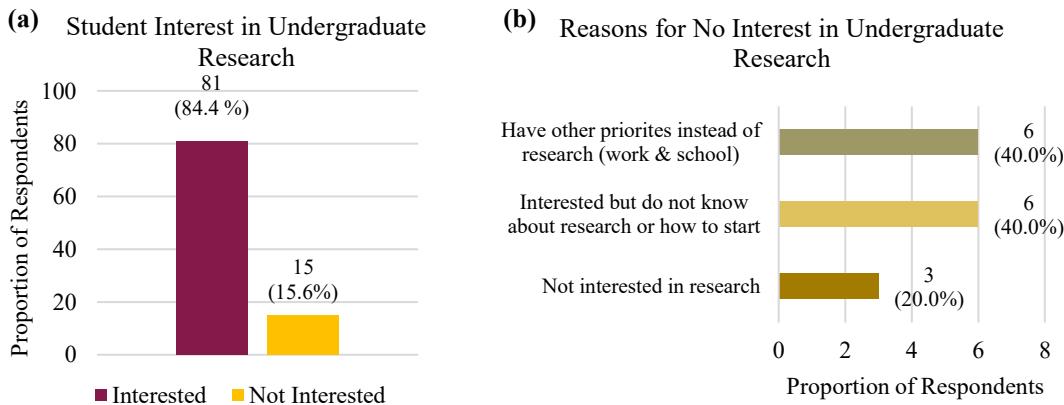


Figure 1: (a) shows the proportion of respondents interested in undergraduate research and (b) shows breakdown of why students are not interested in undergraduate research.

3.3 Student Participation in Undergraduate Research

Survey responses indicate that only 18.52% of the students interested in undergraduate research were actually participating in research. It should be noted that the 15.63% of students that reported no interest in research did not answer this question. This implies that while 84.38% of students are interested in research (Figure 1a), only 18.52% of those students actually engage in research (Figure 2a). To assess why students with interest in research are not participating, students were asked to select a reason or to specify their reasoning. Results showed that 83.08% of students are interested but do not know about research or how to get started, 4.62% have other work or extracurricular obligations, and 12.31% reported their specific reasons (Figure 2b). In the open-ended qualitative responses to this question, students noted that some had already engaged in undergraduate research, were about to graduate, or had plans to participate during the next semester. Moreover, unawareness of research opportunities and unawareness of how to get started in undergraduate research are the main factors for the disparity observed between students that are interested and students that do participate. It is important for faculty and support programs on campus to provide students with information on how to get involved in undergraduate research. Respondents that were participating in research were also asked for an estimate of how many hours per week they spend doing undergraduate research. Their responses were arranged into the following categories: 0 hours to 9 hours (25.00%), 10 hours to 19 hours (66.67%), and 20 hours or more (8.33%).

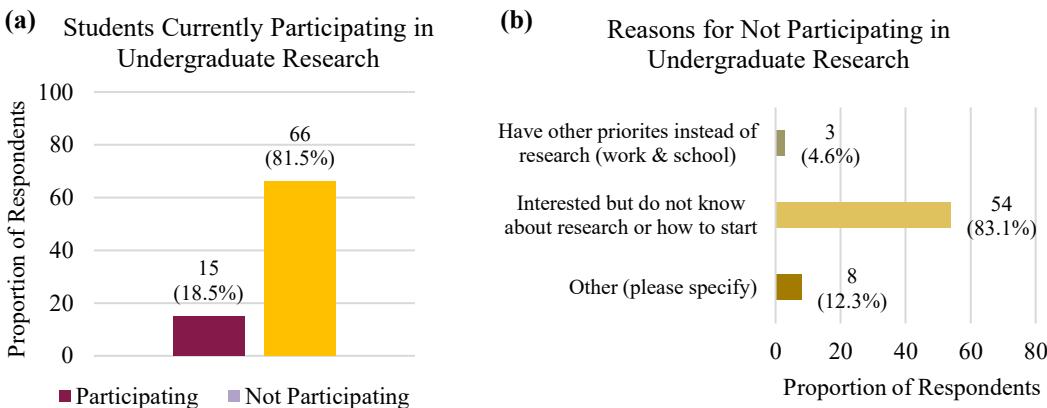


Figure 2: (a) shows the proportion of respondents currently participating in undergraduate research and (b) shows breakdown of why students that are interested in undergraduate research are not currently participating.

4. Discussion

4.1 Perceived Value of Undergraduate Research

Undergraduate STEM students are interested in undergraduate research. However, there are factors that affect their involvement and participation in research. Based on the findings of this study, there appears to be a perceived value assigned to research by students. For some students, undergraduate research is not interesting to them, as seen in **Figure 1b**, so they assign little to no value on engaging in research. Other students are interested in research, but have other priorities (i.e., work, extracurriculars, or school) instead of research. Although they place some value on research involvement, it falls short among their list of priorities. Lastly, there are students that place a high value on research but are unaware of how to get involved in research. This highlights the need to brand and inform students of research opportunities so that they can participate.

4.2 Socioeconomic Factors Affecting Undergraduate Research

Another factor that affects student participation in undergraduate research is the lack of time for research due to work. Given that the majority of the institution's students are considered low income, it is likely that they are maintaining a job while going to school. Based on the responses of students participating in research, 66.67% reported spending about 10 to 19 hours per week, which could add more strain on students balancing work and school. Although the respondents in this study did not disclose their socioeconomic background, they reported time conflicts associated with work to be a reason deterring their interest and participation in undergraduate research (**Figure 1b** and **Figure 2b**). Past research has found that higher income students often have additional resources, and in the context of undergraduate research involvement, it can lead to more availability in their schedule [3]. These students, because of social class, may not need to work off campus and have more time to attend research meetings, perform experiments or generally be available to work with a research mentor [3]. Similarly, first-generation students engage in undergraduate research at lower rates than continuing-generation students. This is because they are often not familiar with the academia culture and struggle to capitalize on opportunities, such as research, internships, or other extracurricular experiences [3, 9]. This phenomenon was observed in the study, whereby respondents often cited a lack of knowledge and awareness of research opportunities. Findings of this study also highlight that there is a gender disparity, especially among engineering students (**Table 1**). Although there is a higher percentage of females enrolled at the university, there is a low percentage of females in STEM majors. Previous research indicates that gender disparities also vary across subfields. Females obtain bachelor's degrees at lower rates in fields of computer science, engineering and physics when compared to biology and chemistry [6, 7]. Underrepresented minorities (i.e., Hispanics, women) might participate less in undergraduate research because of lower self-efficacy and knowledge [10, 11], and lack of representation [8, 11].

4.3 Branding and Advertising of Undergraduate Research

Based on the results of this study, there appears to be an issue with advertising and branding of undergraduate research. The majority of students that were interested in research do not participate because they are not informed on how to get involved. In the open-ended questions, students referred to undergraduate research as a "class" or "course". While there are undergraduate research credits offered, research involvement is not exclusive to students enrolled in the course. Thus, research participation often gets branded as a "course", creating confusion for students as to when or how to get involved in research. Moreover, there is a need to educate students on the benefits that undergraduate research provides since students may not understand the implications that undergraduate research involvement can have on their STEM career. As past research has shown, undergraduate research participation in STEM majors offers students an opportunity to learn technical skills, build important mentoring relationships with faculty and other STEM students, and increase their interest in graduate school [4]. In 2007, Russell et. al. surveyed about 4,500 students participating in National Science Foundation programs. Their study found that 83% of the respondents reported an increase in their research skill confidence, and 68% reported an increase in STEM career interest [12]. Given that as of Fall 2019, 54.9% of all undergraduate students at TAMIU are first-generation, research participation should be discussed more often with students. As previously mentioned, first-generation students often are not familiar with resume-building experiences or struggle to seek help [3]. Therefore, to prevent students from "leaking" out of the STEM pipeline, research participation should be more accessible to students.

5. Limitations

It should be noted that the data collected was part of a cross-sectional design. Since it is a one-time measurement, respondent experiences are likely reflective of their awareness and knowledge at the time each respondent completed the survey. This study does not report on how respondent's research interest and awareness changes over time. Additionally, the findings remain highly relevant as it provides a series of themes affecting undergraduate research awareness and participation that can be further investigated. It should also be noted that the sample structure support the validity of the findings. This is because the majority of respondents were systems engineering majors and biology majors, which are the STEM majors with the most undergraduate research opportunities in the institution. Further research would include a sample including students from other STEM major to examine if there are different levels of research interest and participation across the STEM majors. Additionally, this study focused on student undergraduate research interest and participation only. The findings suggest that there are potentially significant socioeconomic variables that impact undergraduate research awareness and/or involvement, and these should be examined in depth. A follow up study should explore how socioeconomic variables (i.e., social class, ethnicity, income) impact student participation in research.

6. Recommendations

Based on the findings of this research, we provide the following recommendations to increase awareness of undergraduate research opportunities.

- The findings of this study indicate that undergraduate research participation needs to be rebranded. Students often associate research with a "course", rather than understanding that it is a resume-building experience that they can seek themselves. The recommendation is that undergraduate research needs to be introduced/branded into the culture of STEM, especially in disciplines such as systems engineering, physics, or computer science, where there is no set "pipeline" that will lead to undergraduate research involvement. It appears that the disciplines, such as biology and chemistry, undergraduate research participation is far more established (i.e., students know what faculty to contact, where to inquire about research, when during their undergraduate experience they need to engage in research). In theory, integrating undergraduate research participation into the culture of STEM students should increase interest and retention in STEM fields.
- Similarly, undergraduate research needs to be advertised more. For many first-generation students, undergraduate research participation is not something they are aware of. They may not know what research entails, nor how it can impact their STEM career. Therefore, it is important to visualize undergraduate research so that a broader audience can be exposed to it. Creating an environment where students are constantly exposed to research could increase their engagement and interest in it. This concept of visualization can be integrated in course curriculums, social media outreach and even in laboratory design. The idea is that when students are exposed to research, when they see students engaging in research, it will encourage them to participate as well. Along with the advertising of research experiences, there must be a focus in educating students about the value of undergraduate research experiences and process of getting involved in it.

7. Conclusion

This study sought to implement the framework for assessment of undergraduate research awareness in minority-serving institutions as outlined in Khasawneh et al (2020). It was found that while there is substantial interest in undergraduate research, only a small percentage of students actually participate in research. Respondents reported that their lack of interest or participation in research is due to being unaware of research opportunities. From these findings, we propose that undergraduate research needs to be branded into the culture of STEM. By adopting undergraduate research into the culture, it could increase knowledge and engagement in research. Specifically, proper explanation of the impact undergraduate research has on career prospects will be a catalyst for more involvement in research by students. Similarly, research participation needs to be showcased to the students, so that students can visualize what undergraduate research is. Creating an environment that is inclusive, diverse, and effectively communicates the significance of research can bolster the engagement of STEM students in science and engineering degrees.

Acknowledgements

This research was supported by the National Science Foundation Award No. HRD-1911375.

References

- [1] National Science Board, National Science Foundation. (2019). Higher Education in Science and Engineering. Science and Engineering Indicators 2020. NSB-2019-7. Alexandria, VA. Available at <https://nces.ed.gov/pubs/nsb20197/>.
- [2] Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2016). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, 54(2), 169-194. doi:10.1002/tea.21341
- [3] Grineski, S., Daniels, H., Collins, T., Morales, D. X., Frederick, A., & Garcia, M. (2017). The conundrum of social class: Disparities in publishing among STEM students in undergraduate research programs at a Hispanic majority institution. *Science Education*, 102(2), 283-303. doi:10.1002/sce.21330
- [4] Lopatto, D. (2007). Undergraduate Research Experiences Support Science Career Decisions and Active Learning. *CBE—Life Sciences Education*, 6(4), 297-306. doi:10.1187/cbe.07-06-0039
- [5] Khasawneh, M., Kilburn, J. C., Dmello, J. R., Sanchez, D. E., & Segovia, A. (2020, June), A Proposed Survey-based, Student-centered Framework for Evaluation of Undergraduate Research Awareness in Minority-serving Institutions Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual Online. 10.18260/1-2—34038
- [6] National Science Foundation, National Center for Science and Engineering Statistics. (2019). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019*. Special Report NSF 19-304. Alexandria, VA. Available at <https://www.nsf.gov/statistics/wmpd>.
- [7] Casad, B.J., Petzel, Z.W. & Ingalls, E.A. (2019) A Model of Threatening Academic Environments Predicts Women STEM Majors' Self-Esteem and Engagement in STEM. *Sex Roles* 80, 469–488. <https://doi.org/10.1007/s11199-018-0942-4>
- [8] Olivares-Donoso, R., & González, C. (2017). Undergraduate Research or Research-Based Courses: Which Is Most Beneficial for Science Students? *Research in Science Education*, 49(1), 91-107. doi:10.1007/s11165-017-9616-4
- [9] Ostrove, J. M., & Long, S. M. (2007). Social Class and Belonging: Implications for College Adjustment. *The Review of Higher Education*, 30(4), 363-389. doi:10.1353/rhe.2007.0028
- [10] Carter, D. F., Ro, H. K., Alcott, B., & Lattuca, L. R. (2015). Co-Curricular Connections: The Role of Undergraduate Research Experiences in Promoting Engineering Students' Communication, Teamwork, and Leadership Skills. *Research in Higher Education*, 57(3), 363-393. doi:10.1007/s11162-015-9386-7
- [11] Macphee, D., Farro, S., & Canetto, S. S. (2013). Academic Self-Efficacy and Performance of Underrepresented STEM Majors: Gender, Ethnic, and Social Class Patterns. *Analyses of Social Issues and Public Policy*, 13(1), 347-369. doi:10.1111/asap.12033
- [12] Russell, S. H., Hancock, M. P., & Mccullough, J. (2007). THE PIPELINE: Benefits of Undergraduate Research Experiences. *Science*, 316(5824), 548-549. doi:10.1126/science.1140384

Reproduced with permission of copyright owner. Further reproduction
prohibited without permission.