Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46924

High Impact Experiential Learning – An Undergraduate STEM Research Experience for Women in Science and Engineering.

Dr. Lorne S. Joseph, Rutgers, The State University of New Jersey

Dr. Lorne S. Joseph is the Director of Engineering and STEM Research Initiatives at Rutgers-Douglass WiSE and the Director of the Douglass Engineering Living Learning Community. She is an alumna of University of the Virgin Islands (B.S. Chemistry) and the Rutgers School of Engineering (M.S. and Ph.D. in Materials Science and Engineering). Lorne is an ardent steward of STEM with a passion for supporting and mentoring Women in Science and Engineering.

Dr. Lydia Prendergast, Rutgers, The State University of New Jersey

Associate Dean Women in Science and Engineering Interests: Active learning in STEM, experiential learning in STEM, statistically marginalized groups in STEM

High Impact Experiential Learning – An Undergraduate STEM Research Experience for Women in Science and Engineering.

Paper: Practice; Type of Submission: Full

Abstract

Our program prioritizes high impact experiential learning in various forms, including course-based undergraduate research experiences (CURE) for women in STEM. Through these authentic experiences, students are paired with mentors (faculty and advanced peers) and given access to a professional STEM community, university resources, and most importantly an opportunity to develop their STEM identity.

For over 30 years, undergraduate women, early in their education, have engaged in a first-time research experience that has four components: (i) an introductory research course which includes one semester of lab shadowing with university faculty member (ii) 10-week guided summer research (iii) a multi-layered mentor program (iv) and a research poster session. These experiences aim to improve students' ability to persist and remain in their undergraduate STEM majors.

The undergraduate research experience that serves close to 100 women each spring semester includes a recent curriculum update of the introductory research course. This unique course features an active learning classroom element which includes workshops, hands on laboratory experiments, and laboratory techniques. Additionally, students benefit from the support of the course instructor, near- peer mentor, and a five (5) hour per week lab shadowing experience with a research faculty advisor.

Over 70% of the students in the course participate in the 10-week guided summer research opportunity. The summer component of the research experience includes continued support of a near-peer mentor and faculty advisor who help students develop their STEM identity as they strengthen their scientific reasoning through technical understanding of their projects. At the conclusion of the experience, students communicate their findings at a poster session. As a first-time research experience for women in STEM, this CURE highlights the importance of representation and community in research areas where women are still largely underrepresented. A quantitative program assessment was conducted to provide a look on the program's impact on graduation over the last 10 years. The long-standing program proves to be a high impact experience as the results showed that 94% of the students who participated in the program graduated with a STEM/STEM adjacent major.

Introduction

Course-based undergraduate research experiences (CUREs) focus on creating an inclusive research community for students and are excellent first-time research opportunities. Although clear definitions of CUREs vary, the elements they provide remain consistent. Women in STEM who benefit from CUREs that are specifically designed for them participate in a first time tangible and quality research experience, engage in a collaborative learning environment, exercise scientific practices, and receive mentorship and support that address gender disparities in their various disciplines [1-3]. Strategies to increase gender diversity in STEM have been employed nationally over the years, with a focus on various collaborative efforts through programming [4]. Participation in high impact experiential learning opportunities such as research experiences deepen student learning, contribute to retention, and has shown to increase persistence in STEM [5, 6]. The undergraduate research experience is an over 30-year-old multicomponent research program that supports the advancement of undergraduate women in their STEM journeys. The program has provided over 1000 students from over 60 STEM disciplines including engineering, computer science, and the natural sciences the opportunity to work on challenging research projects as a strategy to contribute to the advancement of women in STEM.

Background

In 1998, in work by Fisler *et al*. according to an NSF report, women were not well represented in STEM undergraduate programming and in the workforce. Progress had been made in the achievement and participation; however, it had not been consistent, and full representation had not yet been realized. This report continued that although women are getting closer to representing half of STEM undergraduate degree recipients, their representation in all areas of science and engineering is not on par with that of men [7]. 25 years later, in a recent 2023 report by the National Science Foundation on Diversity in STEM, women earn 50% of science and engineering undergraduate degrees but only make up about 35% of the STEM workforce with the greatest disparities occurring in engineering and the computer sciences [8]. According to work by Smith *et al.* one actionable strategy to contribute to the advancement of women in STEM is to use education as a tool [4]. Doing so by educating others on gender issues in STEM and supporting resources which aim to directly impact achieving gender equity. The persistence of women in STEM in higher education and the STEM workforce has been on the rise but there are many more strides to make. In 1986, a program was established to encourage women to study, explore, and pursue careers in mathematics, the sciences, and engineering. The goal of the program focuses on encouraging entrance into and retention in STEM fields, where women have traditionally been underrepresented [7]. The program introduced various high impact experiential learning opportunities for women, one being an undergraduate research program in 1993. Undergraduate research has been identified as a high impact experiential learning practice that significantly enhances a college student's experience and performance [6, 7]. The goals of the

research program include increasing gender equity in STEM through an impactful first-time research experience by:

1. Curating STEM research opportunities for women in STEM majors and broadening student awareness of these opportunities.
2. Providing students with the necessary research skills to achieve academic and professional success in STEM.
3. Creating an environment and inclusive community to retain women in STEM majors.

The STEM-focused research program has provided undergraduate women with opportunities to engage in active research early in their academic careers. The program goal focuses on undergraduate students working on challenging STEM research projects, aiming to enhance the retention and persistence of women in STEM fields at the undergraduate level and into the workforce.

The program contributes to this goal through four components:

1. Introduction to Scientific Research (ISR) course: a mandatory three (3) credit course which includes a semester long lab shadowing commitment
2. Undergraduate Mentor Program: a near-peer mentoring program where students who have completed the program in a prior year serve as near-peer mentors for the incoming cohort.
3. Summer Research Experience: ten (10) week research experience with a faculty advisor
4. Research Symposium: poster session where students share their research findings

Program Recruitment

Recruitment for the program which includes research faculty, participants, and near-peer mentors, starts during the fall semester of each year October through December.

Research Faculty Advisors

Research faculty are invited to apply through various channels, including in-person interactions, referrals, and email solicitations. On average, up to 60 research faculty participate from over 50 areas in STEM. The faculty cohort is typically made up of 70% men and 30% women. In the interest form, faculty are asked to share what projects they are working on and how many students are they able to accommodate in their lab. Each year, close to 50% of the faculty return. To be considered as a research advisor, faculty must meet the research advisor requirements:

- Research faculty must have an interest in serving as an advisor to undergraduate STEM students
- Research faculty must have a lab and availability to host a student for 5 hours per week during the spring semester
- Research faculty must have a lab and project in which students can participate and can reasonably complete in 10 weeks during the summer

Prior to the start of the course, students are paired with a faculty advisor based on major, research interests, project availability and needs. While exact matches are intended, some students may be paired with a faculty member in a different STEM area other than their majors. All attempts are made to make the pairing as close as possible to the student's major, research interests, skillset, or a combination of those factors.

Program Participants

Students are invited to apply to the program starting first with applying in the fall semester to take the spring semester introductory research course. Invitations are shared through various email solicitations and university research recruitment events. The program receives up to 200 application responses, and close to 100 students are selected to take the course in the spring semester.

The following criteria are considered for selection:

- Students must be majoring in a STEM discipline
- Students must have no prior college level research experience
- Upper-class students are given priority
- A GPA requirement of 2.0 and above, with C's or higher in STEM courses

In addition to meeting the program requirements, applicants must also:

- Share a statement on how their participation in the program will contribute to the advancement of women in STEM
- Share a brief statement about their research interests

Near-peer mentors

Students who have completed the program in a prior year are invited to apply to serve as near-peer mentors for the incoming cohort. Invitations are shared through various email solicitations, online platforms, and various university research recruitment events. The program receives up to 40 applications, out of which eight (8) students are selected to serve as near-peer mentors.

To be considered, applicants must meet the program requirements:

- Students must be majoring in a STEM discipline
- Students must have participated in a college-level research experience
- A GPA requirement of 3.0 and above, with B's or higher in STEM courses

In addition to meeting the program requirements, students must also:

- Share a statement on how their participation in the program will contribute to the advancement of women in STEM
- Share a brief statement about why they want to be a peer mentor

Program Components

Introduction to Scientific Research (ISR) course

The Introduction to Scientific Research (ISR) course is the mandatory three (3) credit course component of the undergraduate research experience offered each spring semester; the curriculum outlines the components necessary for conducting research. At the start of the course, after completing their lab safety and research integrity certifications, students are notified on their faculty pairings, and that lab shadowing begins in February. Midway through the course, students are asked to confirm if they would like to continue with their advisor and participate in the funded summer research component. Over 70% of the students in the course continue in the summer. They have the option of finding a different faculty advisor on their own if they do not wish to continue with their previously assigned lab and advisor. The course is a mandatory prerequisite for participation in funded summer research. The course does not count toward the student's graduation requirements, but it does count toward completion of the university's women's residential college curriculum.

The course includes:

- One weekly classroom session where the students participate in:
  - One hands-on lab-based activities
  - A core research topic (e.g. research misconduct)
  - Completing a discussion post related to the core research topic
- A semester long lab shadowing commitment: the students are paired with a research faculty member for five (5) hours per week.
- The course ends with a "Women in STEM" panel featuring panelists from academia and industry.

The students are taught core research themes and practices, engage with various course activities to solidify the scientific principles, become accustomed to the laboratory/research setting, and interact with their faculty advisor. Students complete hands-on lab activities related to various STEM disciplines represented in the course, some include:

- Research statistics lab
- Completing a simple circuit lab
- Molarity, dilutions, and pipetting lab

A few core research course topics are shared below:

- Research Themes and Practices
- The Scientific Method and Characteristics of Research
- Scientific Integrity
- Scientific Communication: Citations, research articles, abstracts and posters

Learning Outcomes

Following completion of the course, students are expected to:

1. Develop technical research skills and effectively communicate research goals and objectives.
2. Develop networking skills through peer and faculty mentor/mentee relationships.
3. Understand safety in the laboratory as well as proficiency in the practice of ethical research principles through certification.
4. Develop critical thinking skills to understand scientific methods used in STEM research.
5. Develop skills in public speaking through the creation and presentation of a scientific research poster.

Undergraduate Research Near-peer Mentor Program

Students who have previously participated in the program, or a similar undergraduate research program serve as near-peer mentors for the incoming cohort. These mentors help implement the in-class STEM workshops and provide mentoring to the students. The mentors and the mentee groups represent various STEM disciplines. For example, the head mentor is biomedical engineering graduate student, and the mentee group is made up of students majoring in engineering, computer science and the natural sciences. The multi-layered mentoring program focuses on providing near-peer support to students during the spring ISR course and throughout the summer research. Each mentor is assigned a group of mentees consisting of up to 12 students, to whom they provide mentorship and program support throughout the duration of the program. During the program, mentors provide up to two (2) hours of mentoring weekly. Mentor topics, see Table 1, expound on research topics and themes the students complete each week.

Near-peer mentors have the following responsibilities:

- Assisting with implementation of the ISR course lesson plan by facilitating in-class lab activities.
- Attend weekly trainings and meetings with the program director to prepare for the weekly class meeting.
- Host one weekly 30-minute mentor meeting (up to two depending on student availabilities)
- Serve as mentors and program support during summer research, as well as assist with the research symposium.
- Complete a research project during the summer (optional*)
- Compensation:
    - Spring: $1000 stipend for mentoring.
    - Summer: $1000 stipend for mentoring
    - Summer: $1000 for completing a research project*

Table 1: Mentoring Session Topics

Mentoring Session Topics
Identifying Gaps in Your Research
Research and Critical Thinking
Pitfalls in Research
The Importance of Diversity in Research
Women in STEM
Science Communication: Abstracts

Summer Research and the Research Symposium

Students who complete the ISR course transition to the summer research component of the program. Most students continue their research experience in the summer with the faculty member that they were paired with during the spring ISR course. Students also have an opportunity to find a new faculty advisor on their own. Participants receive a $3000 stipend to conduct research for 10 weeks (a minimum of 200 hours of research). Funding for the program is provided by generous university alumnae and corporate donors.

As part of the program during the summer, students also:

1. Attend weekly mentor sessions with their assigned near-peer mentor
2. Complete weekly reflections based on various prompts
3. Attend virtual check-in sessions hosted by the program director and the near-peer mentors
4. Attend two program sponsored events with other university research programs
5. Present their research findings during a poster session early in the fall semester. University leadership, near-peer mentors, research faculty, and student family and friends are invited to attend the symposium in support of the students.

Program Outcomes

For the past three decades, over 1000 students have participated in the undergraduate research program. Outcomes are evaluated through (i) completion of the course, (ii) completion and presentation of a research poster at a poster session. Currently, there are no current program studies to finitely assess, however some students who have participated in the program transition to other research experiences and go on to graduate school. A quantitative program assessment was conducted to determine STEM graduation statistics over the last 10 years. The results of the program assessment (see Table 2.) show that 94% of the students who participated in the program graduated with a STEM/STEM adjacent major. This data highlights that this over 30-year-old program proves to be a successful high impact experience for participating students.

Table 2: Program Graduation Statistics

Graduation Statistics (N=999)	**962**	**96%**
STEM	**843**	**84%**
Engineering	251	25%
Sciences	535	54%
Computing	57	6%
STEM Adjacent	**99**	**10%**
Non-STEM	20	2%
Did not graduate	37	4%
	999	100%

Program Summary

The goal of the undergraduate program to increase gender equity in STEM has not been without its challenges over the years, but the program continues to grow thanks to the support of campus partners which include the supportive faculty some of whom have served as research faculty for the program since its inception. These early and new partners both men and women have shared their enthusiasm for seeing young women succeed in STEM as the reason they continue to support the program. There are many important lessons to be gained from running a legacy program such as this one.

1. The importance of resources (campus partners, alumni, donors)
2. The invaluable importance of collaboration
3. Proper goal setting and planning as well as constant program improvement
4. Flexibility and management of expectations

References

[1] G. Bangera and S. E. Brownell, "Course-Based Undergraduate Research Experiences Can Make Scientific Research More Inclusive," *CBE—Life Sciences Education,* vol. 13, no. 4, pp. 602-606, 2014, doi: 10.1187/cbe.14-06-0099.

[2] Y. Zhu, C. Wang, D. I. Hanauer, and M. J. Graham, "Course-based undergraduate research experiences (CUREs) and student interest development: a longitudinal study investigating the roles of challenge, frustration, and meaning making," *Studies in Higher Education,* pp. 1-16, doi: 10.1080/03075079.2024.2361328.

[3] E. L. Dolan, "Course-based undergraduate research experiences: Current knowledge and future directions," *Natl Res Counc Comm Pap,* vol. 1, pp. 1-34, 2016.

[4] K. A. Smith, P. Arlotta, F. M. Watt, and S. L. Solomon, "Seven actionable strategies for advancing women in science, engineering, and medicine," (in eng), *Cell Stem Cell,* vol. 16, no. 3, pp. 221-4, Mar 5 2015, doi: 10.1016/j.stem.2015.02.012.

[5] M. L. Karlin, H. M. M. Hill, and F. B. Alam, "An immersive field study as an undergraduate research opportunity and additive high-impact practice (HIP) experience for underrepresented students," *SN Social Sciences,* vol. 2, no. 5, p. 58, 2022.

[6] G. D. Kuh, "High-impact educational practices: What they are, who has access to them, and why they matter," *Peer Review,* vol. 14, no. 3, 2012.

[7] J. L. Y. Fisler, John W.; Hein, Jean L., "Retaining Women in the Sciences: Evidence from Douglass College's Project SUPER," *Journal of Women and Minorities in Science and Engineering,* vol. 6, pp. 349-372, 2000.

[8] N. C. f. S. a. E. S. (NCSES), "Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023," in "Special Report NSF 23-315," National Science Foundation, Alexandria, VA, 2023. [Online]. Available: https://ncses.nsf.gov/wmpd