Report

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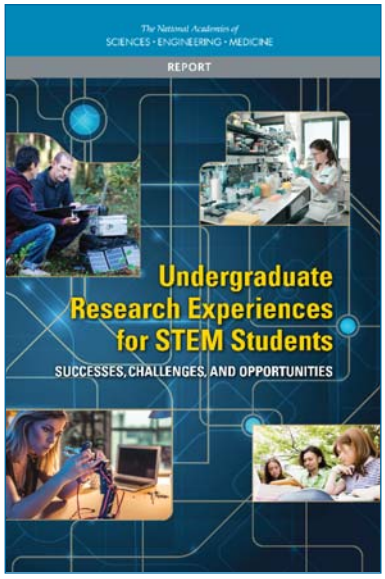
HIGHLIGHTS

Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities



Many ongoing efforts to improve undergraduate education in science, technology, engineering, and mathematics (STEM) fields focus on decreasing traditional lecture-based teaching and increasing the active participation of students. Undergraduate research experiences (UREs), which engage students in the work of STEM professionals, are an example of these efforts. Colleges and universities are offering UREs to students as a way to increase students' interest and persistence in STEM and to broaden participation in these disciplines

Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities (2017), a report from the National Academies of Sciences, Engineering, and Medicine, examines what is known about the effectiveness of UREs. Based on emerging evidence, the report concludes that participation in UREs is beneficial for students and increases their persistence in STEM. The report offers suggestions for development and implementation of UREs that take into account programmatic goals and student learning. It also recommends that researchers, institutions, and funders work together to strengthen the evidence base on these experiences to improve our understanding of how they can benefit students.

A WIDENING RANGE OF UNDERGRADUATE RESEARCH EXPERIENCES

UREs provide meaningful opportunities for students to learn about the work and perspectives of researchers in STEM fields. Attention to UREs has grown significantly in the last few years as calls for action, such as the 2012 Engage to Excel report of the President's Council of Advisors on Science and Technology, have promoted their expansion.

While the classic image of a URE is a student spending the summer working directly with a faculty member on a project related to that faculty

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member's research, UREs have diversified beyond this traditional apprentice model. Course-based UREs are becoming increasingly common. Students also participate in academically relevant research through internships and co-ops outside of the university setting.

The students at undergraduate institutions are increasingly diverse, with growing numbers of historically underrepresented students, first-generation college students, and part-time and other nontraditional students enrolling. Historically underrepresented minorities, women, and first-generation students are less likely to persist in STEM fields; given this, multiple private and publicly funded programs have focused specifically on providing UREs to these groups.

CONSIDERATIONS FOR URE DEVELOPMENT AND IMPLEMENTATION

In light of the recent growth in the number of UREs offered to students, the committee provides practical guidance on factors to consider during the development and implementation of URE programs. These factors include the need to consider the different types of UREs that can be offered and the diversity of the students participating in these experiences. An initial step is to clearly identify the goals of the experiences for students and faculty, the incentives operating on faculty, the resources available, and the campus culture. A plan is needed for how to assess student learning and how to evaluate the program as a whole. Implementation may require creative approaches, such as reconfiguring or repurposing existing resources, exploiting online resources or working with groups beyond the home campus.

WHAT IS KNOWN ABOUT UNDERGRADUATE RESEARCH EXPERIENCES

Research on the effectiveness of UREs is still in the early stages of development compared with other interventions to improve undergraduate STEM education. Most studies of UREs are case studies or use correlational designs, and many of these studies report positive outcomes from participation in a URE. For example, studies focused on students from historically underrepresented groups have used a variety of approaches to show that participation in UREs improves their persistence in STEM and helps them to feel part of the research community.

Only a small number of studies have used research designs that can support inferences about causation, and many questions remain for research—for example, the ways UREs lead to benefits for students, and the aspects of these experiences that are most powerful. To strengthen the research base on these experiences and the benefits for student learning, the report provides a research agenda that offers five research recommendations.

1. Researchers should develop and validate tools that can be readily used by people who direct undergraduate research experiences to assess student outcomes. Assessment should address both conceptual knowledge and development of skills important to STEM professionals. Some of these tools will be useful to those studying UREs in many different disciplines, whereas others will focus on concepts and content of a particular discipline.
2. Future studies should seek to identify and measure the variables that explain why specific aspects of UREs have impact (or not) on the students participating in a URE. Researchers should consider a range of student outcomes (e.g., improved persistence, development of STEM identity, understanding of the nature of research, and development of specific skills or disciplinary knowledge). The number of UREs that a student participates in, the duration of the experience, and the timing of those experiences within the student's undergraduate education should also be examined.
3. Future studies should systematically analyze the impact that various characteristics of UREs have on different student populations, to better identify what works for whom and under what conditions.
4. Researchers should study in a systematic manner the impact of a UREs characteristics on faculty and other mentors to better know the diversity of benefits obtained by faculty and mentors.
5. Additional research should examine the specific role(s) of the mentor and the impact of the mentoring relationship on the undergraduate mentee, compared to the immersive URE itself.

RECOMMENDATIONS

The report offers eight recommendations to improve UREs.

Recommendation 1: Researchers with expertise in education research should conduct well-designed studies in collaboration with URE program directors to improve the evidence base about the processes and effects of undergraduate research experiences. This research should address how the various components of UREs may benefit students. It should also include additional causal evidence for the individual and additive effects of outcomes from student participation in different types of UREs. Not all UREs need be designed to undertake this type of research, but it would be very useful to have some that are designed to facilitate these efforts to improve the evidence base.

Recommendation 2: Funders should provide appropriate resources to support the design, implementation, and analysis of some URE programs that are specifically designed to enable detailed research establishing the effects on participant outcomes and on other variables of interest such as the consequences for mentors or institutions.

Recommendation 3: Designers of UREs should base their design decisions on sound evidence. Consultations with education and social science researchers may be helpful as designers analyze the literature and make decisions on the creation or improvement of UREs. Professional development materials should be created and made available to faculty. Educational and disciplinary societies should consider how they can provide resources and connections to those working on UREs.

Recommendation 4: Institutions should collect data on student participation in UREs to inform their planning and to look for opportunities to improve quality and access.

Recommendation 5: Administrators and faculty at all types of colleges and universities should continually and holistically evaluate the range of UREs that they offer. As part of this process, institutions should

- Consider how best to leverage available resources (including off-campus experiences available to students and current or potential networks or partnerships that the institution may form) when offering UREs so that they align with their institution's mission and priorities.
- Consider whether current UREs are both accessible and welcoming to students from various subpopulations across campus (historically underrepresented students, first generation college students, those with disabilities, non-STEM majors, prospective kindergarten-through-12th grade teachers, etc.).
- Gather and analyze data on the types of UREs offered and the students who participate, making this information widely available to the campus community and using it to make evidence-based decisions about improving opportunities for URE participation. This may entail devising or implementing systems for tracking relevant data.

Recommendation 6: Administrators and faculty at colleges and universities should ensure that all who mentor undergraduates in research experiences (this includes faculty, instructors, postdoctoral fellows, graduate students, and undergraduates serving as peer mentors) have access to appropriate professional development opportunities to help them grow and succeed in this role.

Recommendation 7: Administrators and faculty at all types of colleges and universities should work together within and, where feasible, across institutions to create a culture that supports the development of evidence-based, iterative, and continuous refinement of UREs, in an effort to improve student learning outcomes and overall academic success. This should include the development, evaluation, and revision of policies and practices designed to create a culture supportive of the participation of faculty and other mentors in effective UREs. Policies should consider pedagogy, professional development, cross-cultural awareness, hiring practices, compensation, promotion (incentives, rewards), and the tenure process.

Recommendation 8: Administrators and faculty at all types of colleges and universities should work to develop strong and sustainable partnerships within and between institutions and with educational and professional societies for the purpose of sharing resources to facilitate the creation of sustainable URE programs.

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For More Information . . . This Report Highlights was prepared by the Board on Science Education based on the report, *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities* (2017). The study was sponsored by the National Science Foundation. Any opinions, findings, conclusions, or recommendations expressed in this Report Highlights are those of the authors and do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the DBASSE page at http://nas.edu/STEM_Undergraduate_Research.

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