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

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Motivation for Study

- UREs have rich history & impact for practicing researchers
- Ongoing efforts & calls to improve STEM education & broaden participation
  - PCAST’s Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics
  - AAC&U’s High-Impact Educational Practices: What They Are, Who has Access to Them, and Why They Matter
Report Contents

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Diversity of UREs

• Variation in
  – Structure
  – Goals
  – Participants
  – Disciplinary Context
  – Implementation

• Lack of systematic data collection & evidence

• No set progression of experiences

• Difficult to create concise definition of UREs given variability
Characteristics of UREs

• Engage students in research practices, including the ability to argue from evidence.
• Aim to generate novel information with an emphasis on discovery and innovation or to determine whether recent preliminary results can be replicated.
• Focus on significant, relevant problems of interest to STEM researcher, and in some cases, a broader community.
• Emphasize and expect collaboration and teamwork.
• Involve iterative refinement of experimental design, experimental questions, or data obtained.
Characteristics of UREs

• Allow students to master specific research techniques.
• Help students engage in reflection about the problems being investigated and the work being undertaken to address those problems.
• Require communication of results, either through publications or presentations in various STEM venues.
• Structured and guided by a mentor, with students assuming increasing ownership of some aspects of the project over time.
Model for Stages of Student Research Engagement

- Pre-Research
- Research Project
- Research Experience
- Research Program

➢ Increasing levels of intellectual engagement
➢ Increasing engagement with research team and professional community of practice
➢ Increasing ownership of and responsibility for research project
Types of UREs

- Individual faculty research group (apprentice-style);
- Capstone experiences and senior theses;
- Internships and co-ops;
- Classroom based Undergraduate Research Experiences (CUREs);
- Wrap-around experiences;
- Bridge programs;
- Consortium/project-based programs; and
- Community-based research programs.
Diversity of UREs

Conclusion: UREs are diverse, complex, and exist along a continuum. Not all experiences include all of the characteristics in the same way, varying in emphasis.

Unable to determine how common it is to collect data or what specific information is most often gathered.
Diversity of UREs

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

Administrators & faculty at all types of colleges/universities should continually & holistically evaluate the range of UREs that they offer.
Conceptual Framework

Developed to capture components that impact how UREs are designed, implemented and evaluated

- Part 1: Goals for students & principles for design
- Part 2: Multiple systemic factors of higher ed landscape

Culture & values of campus, department, discipline affect design & implementation of UREs
Research Findings

What is known about UREs?

• Most studies descriptive or correlational

• Focus on participation, retention, & persistence
  – Improve participation & retention in STEM majors & knowledge of career options
  – Mentoring important (historically underrepresented)
Conclusion: Quality of mentoring can make substantial difference in a student’s experiences with research.

Professional development in how to be a good mentor is not available to many faculty or other prospective mentors (graduate students, postdoctoral fellows, etc.).
Recommendation: Administrators and faculty at colleges & universities should ensure that all who mentor undergraduates in UREs have access to appropriate professional development opportunities to help them grow and succeed in this role.
Research Findings

What is known about UREs?

• Develop understanding of STEM disciplinary knowledge & integrate into STEM culture
  – Gains in STEM content learning, data analysis, nature of experimentation, & skill development
  – Feel more comfortable & have positive attitudes about STEM
  – Increased confidence in making research contributions & sense of belonging
Conclusion: Research on efficacy still in early stages.

- Diversity in URE types, goals, questions, & methodologies.
- Literature mostly descriptive/correlational, but report positive outcomes. For historically underrepresented groups, UREs improve STEM persistence & validate disciplinary identity.
- Few studies employ causal research designs, but suggest relationship between URE participation & subsequent persistence.

Committee concludes literature suggests that URE participation is beneficial.
Research Findings

**Recommendation:** URE program directors should collaborate with education researchers to conduct well-designed studies (see Research Agenda).

Funders should provide appropriate resources to support design, implementation & analysis of URE programs specifically designed to increase evidence base.
Research Agenda

- **REC 1:** Develop & validate tools to assess student outcomes (conceptual knowledge & skills development)
- **REC 2:** Identify & measure variables that explain why specific aspects of UREs have impact (or not) on students participating in a URE
- **REC 3:** Systematically analyze characteristics of UREs & impact on different student populations
- **REC 4:** Impact of URE characteristics on faculty & mentors to understand faculty/mentor benefits
- **REC 5:** Examine specific roles of mentor & impact of mentoring relationship
Implementation of UREs

- Considerations for creating, refining, scaling up
  - Make-up of student body
  - Types of programs offered
  - Envisioned goals & outcomes
  - Who will implement and/or serve as mentor
  - Department/Institution constraints, culture, mission
  - Identify any other stakeholder (i.e., funders) needs
  - Capitalize upon resources from national organizations

- Resources - financial, human, space, equipment
- Develop partnerships within/across institutions
- Do programs allow for equity of access?
Implementation of UREs

Conclusions:

• Limited evidence that URE designers use info on strategies for designing, implementing, & evaluating learning.

• STEM faculty do not receive training in interpreting or conducting education research.

• Partnerships between education researchers & URE implementers one way to strengthen evidence use in planning & implementing UREs.

• Access to evaluations of UREs conducted to inform program providers & funders could be beneficial in developing or refining existing programs.
Implementation of UREs

Recommendation: Designers of UREs should base design decisions on sound evidence.
- May need to consult with education & social science researchers.
- Professional development materials should be created & made available to faculty.
- Educational & disciplinary societies should consider how can provide resources & connections.
Thank you!

UREs for STEM Students: Successes, Challenges, and Opportunities

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Future Priorities

• Unique assets, resources, priorities, & constraints of department & institution, as well as individual mentors, impact goals & structures of UREs.

• Schools across country showing considerable creativity in using unique resources, repurposing current assets, & leveraging student enthusiasm to increase research opportunities for their students.
Designing for Sustainability

Administrators & faculty at all types of colleges/universities should work together within & across institutions to

• Create culture that supports development of evidence-based, iterative, & continuous refinement of UREs
• Include development, evaluation, & revision of policies & practices to support faculty/mentor participation
• Policies should consider pedagogy, professional development, cross-cultural awareness, hiring practices, compensation, promotion (incentives, rewards), & tenure
• Develop strong & sustainable partnerships with educational & professional societies to share resources