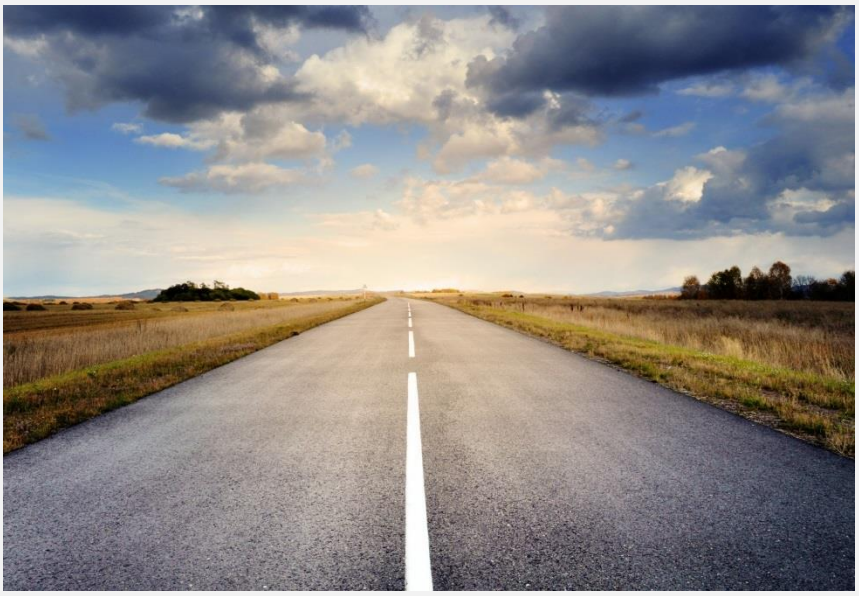

Undergraduate Research: A Road Map for Meeting Future National Needs and Competing in a World of Change

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CUR White Paper No. 1
Council on Undergraduate Research

Printed in the United States of America

ISBN 978-0-941933-07-0

Council on Undergraduate Research
734 15th Street NW • Suite 850
Washington, DC 20005
www.cur.org/

Abstract

The authors present evidence for the role of undergraduate research in college completion and preparation of a highly skilled workforce, particularly in STEM fields.

Introduction: The Needs of Employers and the Nation

Nearly 2 million students graduate from four-year institutions each year (NCES 2013), which would suggest a steady supply of skilled labor to the workforce. Yet employers still lament the dearth of new employees with the appropriate skills to succeed and advance in the workplace. Hart Research Associates (2015) report that more than 80 percent of employers expect students to have strong skills in communication, problem solving, and critical thinking; and more than 90 percent of employers think these skills are more valuable than a student's specific major. Unfortunately, 58 percent of employers do not think recent graduates demonstrate these skills effectively for entry-level positions, and 64 percent feel that recent graduates are not prepared for advancement in a company.

In addition to these critical workforce skills, there is a growing demand in the workforce for skilled labor in science and technology. At the same time, there has been a trend toward declining numbers of degrees in science disciplines. Only 40 percent of students who enter college intent on majoring in science, technology, engineering, and mathematics (STEM) disciplines graduate with STEM degrees, and only 20 percent of underrepresented minority students follow through in STEM (PCAST 2012). Economic projections show the number of STEM degrees earned annually will not meet the nation's demand for more skilled workers such as practitioners, technicians, and manufacturers in myriad health-related fields (PCAST 2012). As a result, the United States is quickly falling behind on filling the science and technology positions necessary to keep the nation as a world leader. The President's Council of Advisors on

Science and Technology (2012) concluded that the United States must increase the number of STEM degrees awarded annually by 34 percent to remain competitive.

The Case for Undergraduate Research in Accomplishing Workforce Goals

Baccalaureate students who have engaged in undergraduate research and creative experiences bring "skills in demand" with them to their first job and are better prepared to apply them successfully. As a means of encouraging and supporting students in STEM disciplines, undergraduate research is a particularly robust tool, and student participation in research has been shown to increase retention, persistence, and graduation rates in these areas (Lopatto 2010).

Higher education institutions carry the responsibility to produce students ready to meet the demands of the workforce with the necessary broad skills as well as the appropriate degrees. Although the STEM disciplines have fully embraced this educational model, this approach is equally important in the arts and humanities (Gilliams et al. 2008; Osgood, Morris, and Rice 2009). Longitudinal assessment data support these claims (Lopatto 2010). Institutions of higher learning are effective at producing workforce-ready graduate students when they offer students the opportunity for active learning or learning by doing (PCAST 2012). Research is the ultimate form of active learning. Students learn to conceptualize a problem, generate potential solutions, test them, and revise the question. Skills developed include perseverance, communication within groups, and ability to collaborate with others in ways that will help them work confidently with peers and supervisors in the workforce.

This is particularly important for achieving the goal of increasing participation by underrepresented populations in STEM fields. These students tend to engage in structured research opportunities in higher percentages than do white, non-Latino students (Hurtado et al. 2014). The structured programs develop communities that benefit black, Latino, and Native

American students, and foster their future academic and research pursuits. Assessment of undergraduate research repeatedly demonstrates its positive educational outcomes both in the short term (early-career) and long term (mid- and late-career; Laursen et al. 2010). As a result, 87 percent of employers stated they were more likely to hire graduates who completed research-based projects (Hart Research Associates 2015), as the mentored research process more effectively develops critical thinking (Ausubel 2000; Handelsman et al 2004), improves motivation and persistence (Lopatto 2007), and builds confidence (Seymour et al. 2004). Students self-report that they feel "better able to think independently and formulate [their] own ideas" (Lopatto 2010, 50). Research experiences help students clarify their career goals (Seymour et al 2004; Lopatto 2003) and encourage them to apply to graduate school (Hathaway, Nagda, and Gregerman 2002). Finally, research involvement early in students' college career helps them to remain in college and persist in STEM majors (Gregerman et al. 1998; Russell, Hancock, and McCullough 2007; Carter, Mandell, and Maton 2009).

Conclusion

A strong economy and a vibrant society thrive on an engaged and well-trained workforce. The evidence that undergraduate research supports these goals is clear. Thus, to accomplish the goal of increasing undergraduate research opportunities, it is essential to support teachers and researchers who invest in these high-impact practices. This support may take many forms, but interested and committed faculty members supported by substantive financial investment can help develop the next generation of creative and critical thinkers. Fostering these resilient and dedicated individuals is critical to maintaining the country's leadership role in finding and implementing innovative solutions to current and future problems. Augmenting federal funding

streams for these high-impact practices will result in a demonstrated return on the investment of public money as the government seeks to strengthen the economy and American society.•

References

Ausubel, David Paul. 2000. *The Acquisition and Retention of Knowledge: A Cognitive View*. Dordrecht, the Netherlands: Kluwer Academic Publishers.

Carter, Frances D., Marvin Mandell, and Kenneth I. Maton. 2009. "The Influence of On-Campus, Academic Year Undergraduate Research on STEM Ph.D. Outcomes: Evidence from the Meyerhoff Scholarship Program." *Educational Evaluation and Policy Analysis*, 31, 441–462. doi: 10.3102/0162373709348584

Gilliams, Teresa, Lawrence Morris, Kristen Woodward, Kennon Rice, and David Osgood. 2008. "Models and Assessment of Collaborative Research in the Arts and Humanities." *CUR Quarterly*, 29(2), 34–37.

Gregerman, Sandra R., Jennifer S. Lerner, William von Hippel, John Jonides, and Biren A. Nagda. 1998. "Undergraduate Student-Faculty Partnerships Affect Student Retention." *Review of Higher Education*, 22(1), 55–72.

Handelsman, Jo, Diane Ebert-May, Robert Beichner, Peter Bruns, Amy Chang, Robert DeHaan, Jim Gentile, et al. 2004. "Scientific Teaching." *Science*, 304, 521–522. doi: 10.1126/science.1096022

Hart Research Associates. 2015. *Falling Short? College Learning and Career Success*. Washington, DC: Association of American Colleges and Universities. https://www.aacu.org/sites/default/files/files/LEAP/2015employerstudentsurvey.pdf

Hathaway, Russel S., Biren A. Nagda, and Sandra R. Gregerman. 2002. "The Relationship of Undergraduate Research Participation to Graduate and Professional Education Pursuit: An Empirical Study." *Journal of College Student Development*, 43, 614–631.

Hurtado, Sylvia, M. Kevin Eagan Jr., Tanya Figueroa, and Bryce E. Hughes. 2014. *Reversing Underrepresentation: The Impact of Undergraduate Research Programs on Enrollment in STEM Graduate Programs.* https://www.heri.ucla.edu/nih/downloads/AERA-2014-Undergraduate-Research-And-STEM-Grad-Enrollment.pdf

Laursen, Sandra, Anne-Barrie Hunter, Elaine Seymour, Heather Thiry, and Ginger Melton. 2010. *Undergraduate Research in the Sciences: Engaging Students in Real Science.* San Francisco: Jossey-Bass.

Lopatto, David. 2003. "The Essential Features of Undergraduate Research." *CUR Quarterly,* 23(3), 139–142.

Lopatto, David. 2007. "Undergraduate Research Experiences Support Science Career Decisions and Active Learning." *CBE–Life Sciences Education*, 6, 297–306. doi: 10.1187/cbe.07-06-0039

Lopatto, David. 2010. *Science in Solution: The Impact of Undergraduate Research on Student Learning*. Washington, DC: Council on Undergraduate Research. Tucson, AZ: Research Corporation for Science Advancement.

National Center for Educational Statistics (NCES), U.S. Department of Education. 2013. *Projections of Education Statistics to 2021* (NCES 2013008). Retrieved from https://nces.ed.gov/programs/projections/projections2021/tables/table_33.asp?referrer=list

Osgood, David, Lawrence Morris, and Kennon Rice. 2009. "How Can an Interdisciplinary Research Program Be Managed Effectively?" *CUR Quarterly*, 30(2), 16–20.

President's Council of Advisors on Science and Technology (PCAST). 2012. *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Washington, DC: Office of Science and Technology Policy, Executive Office of the President. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Russell, Susan H., Mary P. Hancock, and James McCullough. 2007. "Benefits of Undergraduate Research Experiences." *Science*, 316, 548–549. doi: 10.1126/science.1140384

Seymour, Elaine, Anne-Barrie Hunter, Sandra L. Laursen, and Tranee DeAntoni. 2004. "Establishing the Benefits of Research Experiences for Undergraduates: First Findings from a Three-Year Study." *Science Education*, 88, 493–594. doi: 10.1002/sce.10131

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