Fall 2017 Volume 1 • Number 1

SPUR

SCHOLARSHIP AND PRACTICE OF UNDERGRADUATE RESEARCH

The Journal of the Council on Undergraduate Research

Also in this issue:

CUR COUNCIL ON UNDERGRADUATE RESEARCH

SPUR: The Journal of the Council on Undergraduate Research Volume 1 Number 1 Fall 2017

www.cur.org

CUR Council on Undergraduate Research
734 15th Street NW, Suite 850
Washington, DC 20005-1013

Non Profit Org.
U.S. Postage Paid
Hanover, PA
Permit NO. 1541

IN THIS ISSUE OF SPUR

SCHOLARSHIP AND PRACTICE OF UNDERGRADUATE RESEARCH

The Journal of the Council on Undergraduate Research

SPUR SCHOLARSHIP AND PRACTICE OF UNDERGRADUATE RESEARCH

The Journal of the Council on Undergraduate Research

Fall 2017 • Volume 1 • Number 1

Publisher

CUR National Office
Council on Undergraduate Research
734 15th Street NW, Suite 850
Washington, DC 20005-1013
Tel: 202-783-4810
Fax: 202-783-4811
www.cur.org

Design

Afra Bahavar
Seattle, WA
bahavar.afracreative.com

Production and Mailing

The Sheridan Press
Hanover, PA
www.sheridan.com

Scholarship and Practice of Undergraduate Research (SPUR) is published in the fall, winter, spring, and summer by the Council on Undergraduate Research.

The mission of the Council on Undergraduate Research is to support and promote high-quality undergraduate student-faculty collaborative research and scholarship.

SPUR publishes scholarly work that examines effective practices and novel approaches, explores pedagogical models, and highlights the results of assessment of undergraduate research. As a peer-reviewed publication of the Council on Undergraduate Research, the journal provides useful and inspiring information that increases our understanding of undergraduate student-faculty engagement in research, scholarship, and creative work in all disciplines and at all types of higher education institutions in the United States and abroad.

CUR Advertising Policy

The Council on Undergraduate Research accepts advertising from organizations and individuals if such ads are in line with CUR's tax-exempt educational purpose, which is to promote undergraduate research and education. We retain the right to refuse any advertising that we feel does not fall within our guidelines.

For more information, contact the National Office at cur@cur.org or 202-783-4810.

Subscriptions

For CUR members, SPUR is delivered as a benefit of membership. For other individuals, the annual subscription rate is $42. For libraries, the subscription rate is $87 annually.

To order a subscription, visit: www.cur.org/publications.html.

ISSN 2476-101X

Council on Undergraduate Research
734 15th Street NW, Suite 850
Washington, DC, 20005-1013

SPUR SCHOLARSHIP AND PRACTICE OF UNDERGRADUATE RESEARCH
The Journal of the Council on Undergraduate Research

Fall 2017 • Volume 1 • Number 1

CONTENTS

Welcome to the Inaugural Issue of SPUR

James LaPlant, *SPUR Editor-in-Chief*

On behalf of the SPUR Editorial Board as well as the Council on Undergraduate Research, we are very excited to share with our readers the inaugural issue of the *Scholarship and Practice of Undergraduate Research*. SPUR, the acronym for the new title of the journal, captures the powerful action of undergraduate research to encourage, stimulate, hasten, and prompt. Our hope is that SPUR will encourage best practices and models of undergraduate research. Another goal for SPUR is to stimulate the rigorous assessment of undergraduate research initiatives and programs. We also hope to hasten the spread of undergraduate research at colleges and universities across the globe. With the rising competition and growing challenges for funding higher education, our wish for SPUR is to prompt important theoretical discussions about undergraduate research and the future of higher education in the twenty-first century.

These goals are reflected in the redesigned table of contents, which reflects the many aspects of undergraduate research—from assessment and international perspectives to practice and theory. A key topic on all of our campuses is how to effectively and accurately assess undergraduate research experiences. Although we have much to trumpet about the positive impact of undergraduate research, our assessment scholarship still lags behind, especially in relation to direct measures of student learning. The popular international section of the journal has been retained with the recognition that undergraduate research is an expanding global force in higher education. The heart of the journal involves the practice of undergraduate research. The journal has always endeavored to highlight the best practices, models, and lessons learned from undergraduate research initiatives that can be emulated on other campuses. The theory section reflects SPUR as a home for those theoretical discussions and perspectives about undergraduate research as part of the broader framework of higher education. The book review section serves to highlight the latest publications on undergraduate research, and the Undergraduate Research Highlights provide recognition for undergraduates who have recently published with their faculty mentors. In addition to the redesigned table of contents, readers will notice a new cover as well as a redesign of articles. There is no longer any organizational news in CUR's flagship journal. SPUR includes peer-reviewed scholarship from start to finish in each issue, and we have expanded the page count for the volume year to deliver more cutting-edge scholarship on undergraduate research.

I am particularly proud of the lineup of articles for this inaugural issue. In relation to assessment, David Lopatto (Grinnell College) calls for a decreased focus on student dispositions and increased attention to the external validity of undergraduate research programs. He argues that "we can learn more about the nature of undergraduate research by studying groups of programs than by analyzing individual programs." Furthermore, Lopatto argues our assessment studies should focus less on persistence and identity, and focus more upon student decision-making, judgment, and communication. Continuing the theme of assessment, Christopher Barney (Hope College) provides a detailed and insightful analysis of funding decisions for Biology Research Experiences for Undergraduates (REUs) from 1987 to 2014 in relation to the number, funding levels, duration, geographic location, and distribution by institution and principal investigator of site awards. The study finds funding location is highly correlated with population. Doctoral institutions have received the highest percentage of awards, with master's institutions receiving more awards but bachelor's institutions receiving fewer awards. After adjusting for inflation, total funding has not increased since 2003–2006. Jake Follmer, Sarah Zappe, Esther Gomez, and Manish Kumar (Pennsylvania State University) compare an NSF-funded REU program with a university-sponsored REU. Their detailed assessment of the programs involves two different scales with a presurvey and postsurvey design. The comparison of gains across the two REU programs helps to inform program design, duration, and collaboration opportunities. Along similar lines, Pamela Brown and Tammie Cumming (New York City College of Technology–CUNY) and Joan Pasley (Horizon Research, Inc.) compare student survey results for two programs: an Emerging Scholars Program and a Course-Based Undergraduate Research Experience. Student responses are compared in terms of the nature, quality, and impacts of the research experience with the goal of improving both programs.

For the international perspective, Elizabeth Marquis (McMaster University) highlights the powerful model of student-staff partnerships in a Canadian teaching and learning institute. The student partners program emphasizes the potential of "students as producers" of scholarship rather than "students as consumers." In the theory section, Carol Geary Schneider (president emerita of the Association of American Colleges and Universities) issues a clarion call for the development of undergraduate skills in evidence-based inquiry in the wake of recent public policy debates that fly in the face of quantitative data. She notes that too many college seniors graduate with weak critical thinking skills in terms of utilizing evidence and building a strong argument, and one remedy is faculty working together to map inquiry-based learning across the curriculum.

In relation to the practice of undergraduate research, an exciting collection of articles offers diverse institutional and disciplinary approaches that can serve as models for action on any campus. Christopher Kim, Anna Leahy, and Lisa Kendrick (Chapman University) describe a faculty-student research banking (FSRB) program that can be exchanged for a reduced teaching load in a future academic term. The authors outline the rationale, structural components, student and faculty requirements, and faculty usage of banked credits. They also analyze participation rates and cost projections for the FSRB program. Joseph J. Shields and Julio Rivera (Carthage College) and Joseph Wall (Marquette University) describe Velocity Consulting, which is a student-run organization open to Carthage students of any major and class year. The article describes the founding, mission statement, funding, and organizational structure of the consulting group. Velocity Consulting has completed several dozen projects that combine research, scholarship, and creative activities by partnering with companies, government agencies, and nonprofits. Gregory Young, Gary Don, and Alan Rieck provide helpful examples of how to embed undergraduate research and creative activity into the music degree as well as general education courses at Montana State University and the University of Wisconsin–Eau Claire. The authors describe interdisciplinary research projects for undergraduates from freshman year to senior capstone projects.

As we celebrate this inaugural issue, it is also important to recognize that *The Council on Undergraduate Research Quarterly* had a wonderful run from 1980 to summer 2017. For almost four decades, *CUR Quarterly* served to advance the undergraduate research enterprise as one of the most powerful tools to promote student learning and student success. I have been honored to be a part of *CUR Quarterly* over the last 15 years as a division editor, issue editor, and editor-in-chief. I worked with wonderful *CUR Quarterly* editors—from Tom Wenzel and Charlotte Otto to Kelly McConnaughay. Each one advanced the quality and reach of the CUR journal. I am grateful for the work of Herb Childress (chair), Steve Deckelman, Karen Havholm, Jeffrey M. Osborn, and Kathy Payne who served on a 2014 task force that provided incredibly valuable suggestions and recommendations that have come to fruition in this inaugural issue of SPUR. CUR presidents Mary Crowe, Julio Rivera, Ami Ahern-Rindell, Roger Rowlett, and Susan Larson provided critical support over the last several years. This new journal is a reality because of the wonderful vision and support of Elizabeth Ambos (the executive officer of CUR) and Elizabeth Foxwell (the journal's technical editor), as well as the hard work of the CUR Editorial Board. We envision an expanding reach of the journal in the twenty-first century, and the redesign of the flagship journal of the Council on Undergraduate Research is intended to make SPUR an indispensable resource in your personal library.

ASSESSMENT

Adapting to Change: Studying Undergraduate Research in the Current Education Environment

David Lopatto, *Grinnell College*

Abstract

Given that science and science education are undergoing a climate change, the author suggests a re-envisioning of undergraduate research assessment. He argues that continuation of research into the processes and benefits of undergraduate research opportunities for undergraduates will need to decrease focus on student dispositions and increase attention to the external validity of programs. Common dispositional terms such as persistence and identity should give way to the study of student decision making, judgment, and communication. Student adaptability to diverse academic and personal pressures will aid in the understanding of student success.

Keywords: *undergraduate research, external validity, student outcomes, student success, adaptability*

doi: 10.18833/spur/1/1/7

Science and science education are undergoing a climate change. As recently as the PCAST report (2012), it appeared that science was valued nationally, and discussions centered on the production of more science degrees through the prevention of attrition. More recently, faith in the support of the American government for science and science education has been subject to scrutiny. The PCAST theme of increasing science education may be supplanted by retrenchment to cope with reduced federal support (Mervis 2017) and enhanced federal criticism of science (and arts and humanities; Kington 2017). In this angst-driven world, the intended outcomes of education may change. For instance, now it will be increasingly important to teach "ensuring scientific integrity" (Goldman et al. 2017), and for science at least, instructors may face a generation of students who attended secondary school during a time of decreasing public faith in science.

What to do? This essay suggests that now is the time to re-envision how we go about the assessment of undergraduate research, especially in the sciences. In early developments in undergraduate research, it was useful to survey and interview students for the purpose of uncovering the full taxonomy of the benefits of the dedicated undergraduate experience in science research (e.g., Lopatto 2003, 2004a; Seymour et al. 2004) and to examine the generalization of this taxonomy to the social sciences and humanities (Lopatto 2004b). As the study of undergraduate research experiences matured, research efforts branched both vertically, diving into specific features of student characteristics or outcomes of instructional activities (e.g., Hoskins et al. 2011), and horizontally, extending the research program to course-embedded research activities in disciplinary and interdisciplinary courses (Lopatto 2010). Along the way, there have been efforts to tie together various research methodologies to triangulate student learning outcomes (e.g., Shaffer et al. 2014) and calls for a road map of best practices. Fueling some of the research was an attitude, natural to many scientists turned science educators, that the methodology of science would yield significant information about the effects of undergraduate research program features on learning outcomes. Our attention has focused on the relation of teaching and mentoring practices, mediated by student dispositions, to learning outcomes. In considering our next steps, practitioners and program directors may value field research that casts more light on external validity—the generalization from findings about one program to other programs. Research on student behavior should take on the challenge of understanding student decision making and adaptability.

Research on undergraduate research includes a focus on the participants (undergraduate students), the program, and the outcomes of the program. In pursuit of knowledge about students, work has proliferated on student dispositions (for example, grit, persistence, identity, ownership, and a sense of belonging). Typically a survey or scale has been developed, statistical credibility has been achieved, and the disposition is cited as important for the successful undergraduate research experience. Going forward, however, it is unlikely that practitioners will gain much more by the study of these isolated traits. The overarching philosophy of offering the undergraduate research experience is that it permits greater inclusion of diverse students. This valuing of inclusion means that student dispositional information cannot be employed in the traditional sense to select some students but not others for programs. Practitioners will work with all students (Awong-Taylor et al. 2016). Rather than focus on dispositional measures, mentors and program directors will need an omnibus instrument to alert them to program strengths and weaknesses. We could help practitioners assess programs by employing what medical researchers call a *clinimetric measure* (Feinstein 1987). A clinimetric measure is one that permits the practitioner to diagnose the condition of the client or, in this case, the program. A clinimetric measure is not necessarily constrained to one latent variable or construct. One candidate for such a measure is the Survey of Undergraduate Research Experiences (SURE; see Table 1).

The SURE includes a series of student-reported gains that cover many of the critical areas of a successful program. Although the items on this list of gains demonstrate inter-item reliability and differential validity, they do not reflect just one dimension of the experience. Practitioners who have used the SURE, which permits individual programs using small samples to benchmark their results with a larger national data set, often attend to the differences between the item means within their program. Thus, one program enhances its effectiveness in ethical training, whereas another allocates more time to scientific writing. SURE self-report data are unlike the more familiar knowledge measures common in the sciences, and so occasionally reservations about these instruments are raised. First, some educators mistrust student self-report. One useful response to the mistrust of self-report is to implement as assessment plan incorporating a multiple-operational approach that demonstrates agreement in the conclusions drawn from more than one measure (Shaffer et al. 2014). A more significant point is that "direct" measures of learning gains in disciplinary content or method do not show us the attitudes and motives of the student who may be navigating toward a science career. We need to know how students are processing their experience. Thus, clinimetric measures that probe readiness for more research, tolerance for obstacles, and self-confidence are of value to the undergraduate research practitioner. Perhaps the hesitancy to accept student self-report of attitude and motivation is due to researchers' continued use of convenient folk language to describe student behavior—language that suggests that students build up a kind of inertia that carries them forward in their careers. One popular term, *persistence*, can mean the dogged determination with which a student works out a small problem during research; the obsessive nature with which the student completes a course or program despite recommendations to quit; or the sequence of events that lead to graduation, postgraduate education, and a career. As has been stated elsewhere (Lopatto 2015), *persistence* is a word fraught with negative connotation. People report persistent coughs and persistent rashes, not persistent joy about doing research. *Identity* is another term often used, as in helping the student develop a scientific identity. This term is especially problematic, as it competes with powerful discourse on dimensions of identity such as a gender, race, and socioeconomic background. Although there are proffered measures of persistence (Hanauer et al. 2016) and identity (Robnett et al. 2015), it may be more useful to set aside these terms in favor of a decision-making approach. Through the lens of this approach, *persistence* is not a disposition but a set of circumstances that influence a student's decision to continue or stop. *Identity* is a set of cognitive strategies that include "thinking like a scientist" or developing "scientific habits of mind." As opposed to the inertia model, the decision-making model permits an understanding of how students decide to continue or not continue on a career trajectory, and it suggests a fresh line of research on student behavior—namely, investigations of adaptability.

Practitioners of undergraduate research ask for evidence-based practices to employ in their design of programs. *Evidence based* is not the same as *experiment based* (Cartwright and Hardie 2012). Many scientists are trained in the methodology of controlled experiments but have a more modest understanding for phenomena that occur in open, uncontrolled settings. Fortunately, the work of methodologist Donald Campbell on quasi-experiments (Campbell and Stanley 1966; Campbell 1969, 1982) and more recently the work of Nancy Cartwright on policy implementation (Cartwright and Hardie 2012) provide frameworks for performing and interpreting the sorts of studies that analyze the process and benefits of undergraduate research. Campbell's work provides remedies for the problem of a lack of randomly assigned control groups, whereas Cartwright's work helps us understand how a program that "worked there" may "work here"—that is, how it achieves external validity. In the context of undergraduate research programs, the view shared by these writers indicates that the external validity of programs, the generalizability of practices across programs and

TABLE 1. Self-Evaluation Items for Student Respondents on the SURE Survey

Item	Continuing	Leaving
Clarification of a career path	3.60	3.04
Skill in the interpretation of results	3.75	3.32
Tolerance for obstacles faced in the research process	3.95	3.52
Readiness for more demanding research	3.94	3.41
Understanding how knowledge is constructed	3.69	3.23
Understanding of the research process in your field	3.96	3.63
Ability to integrate theory and practice	3.70	3.23
Understanding how scientists work on real problems	3.91	3.58
Understanding that scientific assertions require supporting evidence	3.66	3.18
Ability to analyze data and other information	3.77	3.50
Understanding science	3.67	3.26
Learning ethical conduct in your field	3.37	3.01
Learning laboratory techniques	3.85	3.15
Ability to read and understand primary literature	3.64	3.20
Skill in how to give an effective oral presentation	3.55	2.95
Skill in science writing	3.30	2.86
Self-confidence	3.62	3.17
Understanding of how scientists think	3.64	3.10
Learn to work independently	3.83	3.46
Becoming part of a learning community	3.68	3.29
Confidence in potential to be a teacher of science	3.40	2.71

Note: Responses are scaled from 1 (no or very small gain) to 5 (very large gain). The means shown above are from a comparison of students (N = 1469) who, at the conclusion of their undergraduate research experience, continued to plan for an advanced degree in the field and students (N = 136) who, at the conclusion of the research experience, decided to leave the path to an advanced science degree. The instructions ask students to consider how much they benefited from their research experience. These sample results show how the survey may highlight relevant differences between continuing and leaving students on career path clarification, readiness for more demanding research, understanding of how scientists think, and confidence in science teaching potential.

institutions, yields valuable insights into the core features and outcomes of undergraduate research.

We can learn more about the nature of undergraduate research by studying groups of programs than by analyzing individual programs. One such collaborative is the Genomics Education Partnership (GEP), founded by Sarah Elgin (Washington University in St. Louis). The GEP includes about 100 institutions of higher learning. Its collective success brings to mind a classic method of discovery, often attributed to the philosopher John Stuart Mill, called the *method of agreement* (Cook and Campbell 1979). If two or more instances (programs) of a phenomenon under investigation (learning genomics) have only one circumstance in common (the features of the GEP), then the circumstance shared by all the instances is the cause of the given phenomenon. The GEP comprises diverse instances of the phenomenon of teaching genomics in the context of undergraduate research. These instances are institutions: universities, small liberal arts colleges, and community colleges with highly varied student populations. The overall success of the consortium has been attributed to its distinct, shared features that represent one model for undergraduate research in science education. These shared features include program goals, lab activities, common training of instructors, and a central support site, whereas the institutions differ in myriad ways, including size, mission, and admission selectivity (Shaffer et al. 2010).

One relatively unexplored environmental feature of individual and groups or programs is the extent to which a program, nominally dedicated to undergraduate research, is supported by other features of the learning environment. On most campuses, there are resources external to the specific course or research experience that influence student success. Many institutions have developed academic support services to facilitate student success, including teaching and learning centers, writing centers, peer education programs, and the like. Future studies of undergraduate research and its influence on student learning will need to take these moderating influences into account. What is the influence of these support services? How do they impact student decisions? Do they ameliorate problems that may interfere with student success? Support services are one source of the broader "support factors" discussed by Cartwright (Cartwright and Hardie 2012) that we need to study in order to understand how successful undergraduate research programs may generalize to new institutions and students.

Topics Deserving Increased Attention

Judgment and Communication

With current techniques and instrumentation, even novice students may make contributions to the catalog of scientific knowledge (e.g., Jordan et al. 2014). With improvements in technology, it is likely that contributions to a global encyclopedia of knowledge, the identification of objects from phage to exoplanets, will accelerate. What has not declined, however, is the student's challenge to learn the provisional nature of knowledge and the influence of the researcher on the material being researched. From bioinformatics to statistics, there is a moment in which human judgment plays a critical role, and this role has not been replaced by automated systems. The outcome of a scientific investigation (as well as investigations in social science and humanities) does not end with a "correct" answer but rather with a conclusion that has been well thought out, well communicated, and well received. This ability to communicate, to express that outcome of trained human judgment, is precisely what will emerge as a key component of scientific influence in the current political climate. Communication skills will need to expand out from the internal exhibitions of posters and papers that are nested inside the disciplinary community. The ability to communicate science to a broader audience should come to the increased attention of program directors and assessment experts. A moment's reflection on public confusion over global climate change should convince us that this broader communication is important. There are some examples of learning scientific communication in the context of service learning (e.g., Harrison et al. 2013), and the topic deserves more scrutiny.

Student Adaptability

The optimal description of the undergraduate research experience is the summer in the lab or field, an experience of 8–10 weeks in which the student has no concerns except to focus on his or her research under the guidance of a mentor. This immersive experience may mislead us to think that the student is developing into a specialist, prioritizing his or her research interest above other considerations. During the academic year, however, the student must learn to balance the pressures of multiple courses and laboratories, as well as working and social life. We may wonder how a student develops an interest, for example, in a science, within an environment where the student must attend other courses and attend to other challenges. How is the promising biology major behaving in sociology class? History? Art? The students we see as promising scientists may also be promising social scientists and humanists. They may have learned to adapt, to "think like a scientist" in a science ecosystem, and to shift to "think like a historian" in a different ecosystem. This adaptability may carry on to later decision points in a student's life, accounting for decisions to attend graduate school, to apply for a job in the STEM workforce, to continue a STEM career, and so on. Recent political events have highlighted the lack of public understanding of science, which in turn may lead the promising science student to change career trajectory. Similarly, social science, humanities, and art are facing lack of public understanding and institutional support (Fallon 2017; Wermund 2016). At the institutional level, "student success" is frequently defined as a graduation rate without regard to major or program. Decisions to change a major or program may be neglected by administrators who are satisfied with overall graduation rates, but we need to know the patterns of student decision making within the institution. It may be that the Council on Undergraduate Research is well positioned to encourage studies of student adaptability, as its members include many scholarly disciplines.

Conclusion

The most insistent motivation for studying undergraduate research and its effects is to learn how to replicate the successful features of the process. The PCAST (2012) report invoked the need for 1 million new science degrees, and in the current political climate the need for science education seems more pressing than ever. Campbell (1986) suggested that focusing on the external validity of programs is the optimal strategy for understanding the validity of the construct itself. In principle, then, our continued attention to successful undergraduate research programs should teach us what works. But undergraduate research programs, whether stand-alone or embedded in a course, are not experiments in which initial conditions are prepared and then the experiment allowed to run its course with no further interventions, nor are they closed systems immune to exogenous variables. No responsible research mentor or course instructor would watch with disinterest as students failed to learn due to faulty experimental program conditions; and no program runs in a vacuum devoid of family or financial events affecting students. One study (Lopatto 2015) reported on undergraduates who reversed their decision to commit to a two-year research program and on alumnae who stopped pursuing science after graduation, despite experience with undergraduate research. These cases did not represent program failure. They demonstrated the influence of exogenous factors beyond the control of the program. They also represented the decision making continuously undertaken by people as they journey through life events.

Finally, there is a problem inherent to theories about research experiences and the students they affect. Theories concerning persistence, identity, ownership, efficacy, self-confidence, grit, or belonging are not exclusive to each other when being employed to make sense of student success. That is, there will always be more than one way to account for the data. Practitioners will likely remain eclectic in their approach to program design. This eclecticism may be a useful strategy in an era of changing climate for undergraduate research.

References

Awong-Taylor, Judy, Alison D'Costa, Greta Giles, Tirza Leader, David Pursell, Clay Runck, and Thomas Mundie. 2016. "Undergraduate Research for All: Addressing the Elephant in the Room." *CUR Quarterly* 37(1): 11–19. doi: 10.18833/curq/37/1/4

Campbell, Donald T. 1969. "Reforms as Experiments." *American Psychologist* 24: 409–429. doi: 10.1037/h0027982

Campbell, Donald T. 1982. "Experiments as Arguments." *Knowledge: Creation, Diffusion, Utilization* 3: 327–337.

Campbell, Donald T. 1986. "Relabeling Internal and External Validity for Applied Social Scientists." In *Advances in Quasi-experimental Design and Analysis*, ed. William M. K. Trochim, 67–77. San Francisco: Jossey-Bass. doi: 10.1002/ev.1434

Campbell, Donald T., and Julian C. Stanley. 1966. *Experimental and Quasi-experimental Designs for Research*. Chicago: Rand McNally.

Cartwright, Nancy, and Jeremy Hardie. 2012. *Evidence-Based Policy: A Practical Guide to Doing It Better*. Oxford: Oxford University Press. doi: 10.1093/acprof:osobl/9780199841608.001.0001

Cook, Thomas D., and Donald T. Campbell. 1979. *Quasi-experimentation: Design & Analysis Issues for Field Settings*. Boston: Houghton Mifflin.

Fallon, Claire 2017. "Arts Advocates Denounce Proposed Elimination of the NEA and NEH." *Huffington Post*, March 16. http://www.huffingtonpost.com/entry/arts-advocates-denounce-proposed-elimination-of-the-nea-and-neh_us_58ca93dfe4b00705db4c88a2?9xexw5mcsw03eg66r&section=us_arts

Feinstein, Alvan R. 1987. *Clinimetrics*. New Haven: Yale University Press.

Goldman, Gretchen T., Emily Berman, Michael Halpern, Charise Johnson, Yogin Kothari, Genna Reed, and Andrew A. Rosenberg. 2017. "Ensuring Scientific Integrity in the Age of Trump." *Science* 335: 696–698. doi: 10.1126/science.aam5733

Hanauer, David I., Mark J. Graham, and Graham F. Hatfull. 2016. "A Measure of College Student Persistence in the Sciences (PITS)." *CBE–Life Sciences Education* 15: ar54, 1–10. doi: 10.1187/cbe.15-09-0185

Harrison, Melinda, David Dunbar, and David Lopatto. 2013. "Using Pamphlets to Teach Biochemistry: A Service-Learning Project." *Journal of Chemical Education* 90: 210–214. doi: 10.1021/ed200486q

Hoskins, Sally G., David Lopatto, and Leslie M. Stevens. 2011. "The C.R.E.A.T.E. Approach to Primary Literature Shifts Undergraduates' Self-Assessed Ability to Read and Analyze Journal Articles, Attitudes About Science, and Epistemological Beliefs." *CBE–Life Sciences Education* 10: 368–378. doi: 10.1187/cbe.11-03-0027

Jordan, Tuajuanda C., Sandra H. Burnett, Susan Carson, Steven M. Caruso, Kari Clase, Randall J. DeJong, John J. Dennehy, et al. 2014. "A Broadly Implementable Research Course in Phage Discovery and Genomics for First-Year Undergraduate Students." *mBio* 5(1): e01051-13. doi:10.1128/mBio.01051-13

Kington, Raynard S. 2017. "A Scientist Speaks for the Arts and Humanities." *Inside Higher Ed,* March 20. https://www.insidehighered.com/views/2017/03/20/scientist-speaks-out-against-proposed-elimination-national-endowments-arts-and

Lopatto, David. 2003. "The Essential Features of Undergraduate Research." *CUR Quarterly* 24(3): 139–142.

Lopatto, David. 2004a. "Survey of Undergraduate Research Experiences (SURE): First Findings." *Cell Biology Education* 3: 270–277. doi: 10.1187/cbe.04-07-0045

Lopatto, David. 2004b. "What Research on Learning Can Tell Us About Undergraduate Research: Crossing Boundaries." Presentation at the Conference of the Council on Undergraduate Research, La Crosse, WI, June 23–26. http://web.grinnell.edu/science/ROLE/Presentation_2004_CUR_annual_meeting_WI.pdf

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

Lopatto, David. 2015. "The Consortium as Experiment." In *Integrating Discovery-Based Research into the Undergraduate Curriculum: Report of a Convocation*, 101–114. Washington, DC: National Academies Press.

Mervis, Jeffrey. 2017. "Trump's 2018 Budget Proposal 'Devalues' Science." *Science* 355: 1246–1247. doi: 10.1126/science.355.6331.1246

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: U.S. Government Office of Science and Technology.

Robnett, Rachael D., Martin M. Chemers, and Eileen L. Zurbiggen. 2015. "Longitudinal Associations among Undergraduates' Research Experience, Self-Efficacy, and Identity." *Journal of Research in Science Teaching* 52: 847–867. doi: 10.1002/tea.21221

Seymour, Elaine, Anne-Barrie Hunter, Sandra L. Laursen, and Tracee Deantoni. 2004. "Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-Year Study." *Science Education* 88: 493–534. doi: 10.1002/sce.10131

Shaffer, Christopher D., Consuelo Alvarez, Cheryl Bailey, Daron Barnard, Satish Bhalla, Chitra Chandrasekaran, Vidya Chandrasekaran, et al. 2010. "The Genomics Education Partnership: Successful Integration of Research into Laboratory Classes at a Diverse Group of Undergraduate Institutions." *CBE–Life Sciences Education* 9(1): 55–69. doi: 10.1187/09-11-0087

Shaffer, Christopher D., Consuelo J. Alvarez, April E. Bednarski, David Dunbar, Anya L. Goodman, Catherine Reinke, Anne G. Rosenwald, et al. 2014. "A Course-Based Research Experience: How Benefits Change with Increased Investment in Instructional Time." *CBE–Life Sciences Education* 13: 111–130. doi: 10.1187/cbe-13-08-0152

Wermund, Benjamin. 2016. "Science Funding in the Age of Trump." *Politico*, November 17. http://www.politico.com/tipsheets/morning-education/2016/11/science-funding-in-the-age-of-trump-217460

David Lopatto
Grinnell College, lopatto@grinnell.edu

David Lopatto is professor of psychology and Samuel R. and Marie-Louise Rosenthal Professor of Natural Science and Mathematics at Grinnell College. He directs the Grinnell College Center for Teaching, Learning, and Assessment. He has been studying the features and benefits of undergraduate research experiences for many years, most recently with the support of funding from the Howard Hughes Medical Institute to conduct national online surveys, including the Survey of Undergraduate Research Experiences (SURE) and the Survey of Classroom Undergraduate Research Experiences (CURE).

ASSESSMENT

An Analysis of Funding for the NSF REU Site Program in Biology from 1987 to 2014

Christopher C. Barney, *Hope College*

Abstract

Using data available at the NSF Search Awards site, Biology REU Site awards made from 1987 to 2014 were analyzed. During this time, there was an average of 30.8 new REU Site awards per year with an average duration of three years. Total funding for Biology REU Site awards increased for each four-year period analyzed since 1995–1998 in actual dollars but has not increased substantially in inflation-adjusted dollars since 2003–2006. Average award funding in inflation-adjusted dollars increased from 1987–1990 to 2003–2006, which reflects the increased duration of awards, and then declined slightly for the 2007–2010 and 2011–2014 periods. Awards have been made to institutions in every state except Wyoming as well as to institutions in Washington, DC, and Puerto Rico. The total Biology REU Site funding per state/location is highly correlated with the state/location population. Awards have been made to 257 institutions and to 480 principal investigators (PIs). Many institutions (33.8 percent) and PIs (56.7 percent) have had only one Biology REU Site award, whereas 10.5 percent of the institutions and 0.4 percent of the PIs have had eight or more awards. Doctoral institutions had the largest percentage of awards (65.5 percent), followed by research institutes, master's institutions, bachelor's institutions, medical institutions, associate's institutions, and tribal colleges. From the 1987–1990 to the 2011–2014 analysis periods, the percentage of awards made to master's institutions increased from 9.6 percent to 15.3 percent, and the percentage of awards made to bachelor's institutions decreased from 13.3 percent to 2.1 percent.

Keywords: *biology, funding, REU Sites, National Science Foundation*

doi: 10.18833/spur/1/1/1

Introduction

In 1987, the National Science Foundation (NSF) initiated the Research Experiences for Undergraduates program (REU) (http://www.nsf.gov/funding/pgm_ summ.jsp?pims_id=5517&from=fund). The REU program offers primarily two types of awards. REU Supplements provide funds to NSF research award recipients to support one or two undergraduate students working on their research projects. REU Sites provide funds for 6 to 12 students working with usually more than one scientist on research projects related to a common theme. REU Site awards have some similarities to the earlier awards for the NSF Undergraduate Research Participation program (URP), although the URP program did not usually require the recruitment of students from outside of the institution (Doyle 1987). The URP program ran from 1959 until 1981, when it was terminated despite calls for its continuation (Doyle 1987; Neckers 1982). The author participated in an NSF URP program in biology at Wright State University in summer 1972 and directed an NSF REU Site program at Hope College for several years. Although the Hope College Biology Department had REU support for 24 years, the department has been unsuccessful in obtaining further funding. Such developments led to an analysis of NSF Biology REU Site funding data to determine if there were any trends in funding that might relate to the department's grant success rate. In addition to discovering other interesting data, it was found that the percentage of Biology REU Site grants awarded to institutions that award primarily bachelor's degrees has declined considerably since the first few years of the program. This article analyzes NSF Biology REU Site program funding from 1987 to 2014 in terms of numbers of awards; award and program funding levels; and distribution of awards by location, institution, principal investigator (PI), and type of institution.

The impacts of undergraduate research in science, technology, engineering, and math (STEM) fields on the research participants have been studied extensively in the last 25 years, and many positive effects of research participation have been documented. Lopatto (2004, 2007, 2009) reported that participation in undergraduate research led to gains in areas such as understanding the process of research and ways in which scientists work, learning lab techniques and methods of working independently, analyzing data and interpreting results, integrating theory and practice, clarifying the career path, and building self-confidence. There were no clear differences in these gains among students who performed research at colleges, master's-level institutions, or research institutions, but the quality of mentoring was important in the satisfaction level of the undergraduate participants. Using interviews of research students rather than surveys, Seymour and colleagues (2004) found similar outcomes with positive benefits noted in areas such as improving research and communication skills, working and thinking like a scientist, clarifying the career path, and preparing for graduate school. The Undergraduate Research Student Self-Assessment instrument now in use to assess REU Sites provided data showing that students who participated in undergraduate research had self-reported gains in research skills, career clarification and preparation, and the process of working and thinking like a scientist (Hunter et al. 2009).

Thiry and colleagues (2013) reported that, as time spent doing research increased, generalized problem-solving, understanding how to collect data, analyzing data for patterns, and building personal confidence in the ability to do research also increased. Schmitz and Havholm (2015) reported on the results of a survey of their institution's alumni who had participated in undergraduate research. The alumni reported that undergraduate research led to gains in higher-order thinking skills and personal development as well as gains in discipline-specific areas. Comments made about their research experiences by the survey respondents were very positive and included praise for faculty mentoring as well as preparing for graduate school and careers.

Participation in undergraduate research has also been shown to affect career choice and satisfaction. Lopatto (2007) found that undergraduate research either increased or maintained students' interest in advanced study in a STEM field or medicine with 45 percent of the survey respondents indicating a plan to obtain a PhD in a STEM field. Yaffe and colleagues (2014) reported that a survey of participants in the Undergraduate Biology Research Program at the University of Arizona from 1988 to 2010 showed that 45 percent had obtained or were in the process of obtaining a PhD degree, and 7 percent had obtained or were obtaining both the MD and PhD degrees. In addition, they found that presenting or publishing the research results and interactions with a mentor were identified as influences on career path by 24 percent and 35 percent of the respondents respectively, whereas 81 percent of the respondents indicated personal interest as an influence. Eagan and colleagues (2013) reported that undergraduate research participation significantly increases the intent of students to pursue graduate school in some STEM field.

There have also been studies on how students select REU programs and the impact of the NSF REU program in general. A recent paper by Economy and colleagues (2014) provides both a review of history of the REU program and an analysis of factors used by students in making decisions about applying for and participating in a REU program. The primary factors were the focus of the particular project, the level of the stipend, the date of the offer, and the housing and meal plan offered. They also reported that most applicants applied to four or more programs.

The first three years of the REU program were evaluated by Fitzsimmons, and the results were summarized in a report from NSF (1990). At that time, 10 percent of the participants had finished only one or two years of college, 43 percent were female, 10 percent belonged to minority groups underrepresented in STEM fields, and 59 percent were from predominantly undergraduate institutions. They also reported that participation increased plans to seek a PhD The results of a later study on NSF's support for undergraduate research were reported by Russell (2006) and summarized in *Science* (Russell et al. 2007). They reported that women composed 53 percent of the NSF-supported undergraduates, 27 percent of the participants belonged to minority groups underrepresented in STEM fields, and first- and second-year students still made up a small percentage of the total participants. These investigators found that 68 percent of the undergraduates who participated in research with support from NSF reported an increased interest in a STEM career, and 29 percent reported an expectation of obtaining a PhD that did not exist prior to research participation. In addition, undergraduate research increased awareness of expectations at the graduate school level, increased confidence in research skills, and increased understanding of how to do research. Increasing enthusiasm of students for research was seen as a major effect of an undergraduate research experience, and involving more students who had finished only one or two years of college was a recommendation that emerged from the study.

Beninson and colleagues (2011) reported on the results of a four-year survey of Biology REU Site directors that was updated by O'Connor (2014). They reported that, from 2006 to 2013, the number of applications to Biology REU Sites doubled, whereas the success rate for applications decreased from 7.8 percent to 4.3 percent, that the percentage of participants from external institutions ranged from 82 percent to 90 percent, that about 63 percent of the participants have been female and about 47 percent have belonged to minority groups underrepresented in STEM fields, and that more than 50 percent of the participants had just completed their junior year. Benison and colleagues (2011) also reported that most REU Sites include workshops, seminars, research presentations, and social events as part of the REU Site activities. The measurements of program success by the PIs included matriculation at graduate school, presentation or publication of results, and general satisfaction with the program. Further, it was suggested that individuals seeking REU Site funding consider NSF's goals of increasing the number and diversity of the students who apply for positions and the benefits of including younger students in a program, as well as involving the students in cutting-edge research.

These reports provide important information about the REU Site Program in Biology and demonstrated that the NSF REU and other NSF undergraduate research support programs were accomplishing the goals of providing undergraduates with intensive research experiences, increasing the diversity of undergraduate students participating in research, increasing interest in STEM careers, and increasing the numbers of students who had earned or who expected to earn a PhD in a STEM field. In the spirit of these reports, the following details regarding the history of funding of NSF Biology REU Sites are offered.

Funding for the NSF Biology REU Site Program, 1987–2014

Methods

To obtain information about NSF Biology REU Site funding, NSF Search Awards site (http://www.nsf.gov/awardsearch/) was accessed on October 12, 2015, and two searches were conducted:

- A search for active and expired awards under NSF Organization DBI BIO (Directorate for Biological Sciences) and Program Code=9250, Research Experiences for Undergraduate Sites, from 1/1/1987 to 12/31/2014.
- A search for active and expired awards under NSF Organization DBI BIO and Keyword=REU from 1/1/1987 to 12/31/2014.

The results were downloaded, the files were combined, and duplicate awards were eliminated. Using the award titles and abstracts, awards with REU in the title that had been made through the Division of Environmental Biology were eliminated, as these were not Research Experiences for Undergraduates awards, and other awards that included REU in the abstract but were not Biology REU Site awards were also eliminated.

REU awards that were made for funding an activity other than a REU Site were then eliminated. Omitted were five awards to support workshops for Biology REU Site directors (in 2003, 2007, 2010, 2012, and 2014 for a total of $352,412), three awards to evaluate site programs (all in 2010 for a total of $144,617), one to review and develop modules on ethics in research (in 2011 for $97,461), three to support travel of REU students to meetings and miscellaneous support (in 2010, 2012, and 2013 for a total of $317,996), and two to develop a common tracking tool and a long-term outcomes assessment (both in 2012 for a total of $41,234). This left 863 awards for analysis. Analysis was primarily carried out using the PivotTable function of Excel. It is important to note one major limitation of this study is the completeness and accuracy of the data obtained from searching for Biology REU Site awards using the NSF Search Awards system. For several figures, the data were divided into seven four-year intervals covering the period 1987–2014.

Number of New Awards

Figure 1A shows the number of new Biology REU awards during each four-year period. Award numbers have been fairly steady except for the periods 1995–1998 and 1999–2002, when award numbers were 59 percent and 81 percent of the average number of awards for the other periods. The number of awards may reflect both funding levels for the Biology REU program at NSF and the duration of awards. There was a small decline in the overall NSF budget during 1996–1998, with $3.56 billion budgeted in 1995 and with an average of $3.50 billion per year from 1996 to 1999 (AAAS 2016). As seen in Figure 2B, average award duration increased substantially during the second and third periods. As NSF committed more funding to continue REU Sites for longer periods of time, less funding was available to support new proposals.

Total Funds Awarded

Figure 1B shows the total funds awarded for the four-year periods in both actual and inflation-adjusted amounts. The inflation-adjusted amounts were determined using 1987 as the baseline and multiplying the actual amounts by the Consumer Price Index impact for each year (U.S. Department of Labor 2016). Actual award dollars for Biology REU Site awards increased for each four-year period except for 1995–1998, when there was an 8 percent decrease from the previous four-year period. Inflation-adjusted award dollars increased by 62 percent from 1995–1998 to 1999–2002 and by 57 percent from 1999–2002 to 2003–2006 but have remained steady at approximately $21.6 million per period since then. Thus, the NSF Biology REU site program has shown no real growth in the last 8–10 years, which should be of concern to those involved in training the next generation of biology research scientists and others for the STEM workforce.

Figure 1C shows the average funds per award for the four-year periods in both actual and inflation-adjusted amounts. The actual average award dollars increased for every year of the program from approximately $50,000 per award in 1987–1990 to approximately $315,000 per award

FIGURE 1. Numbers and Funding Levels of Biology REU Site Awards, 1987–2014

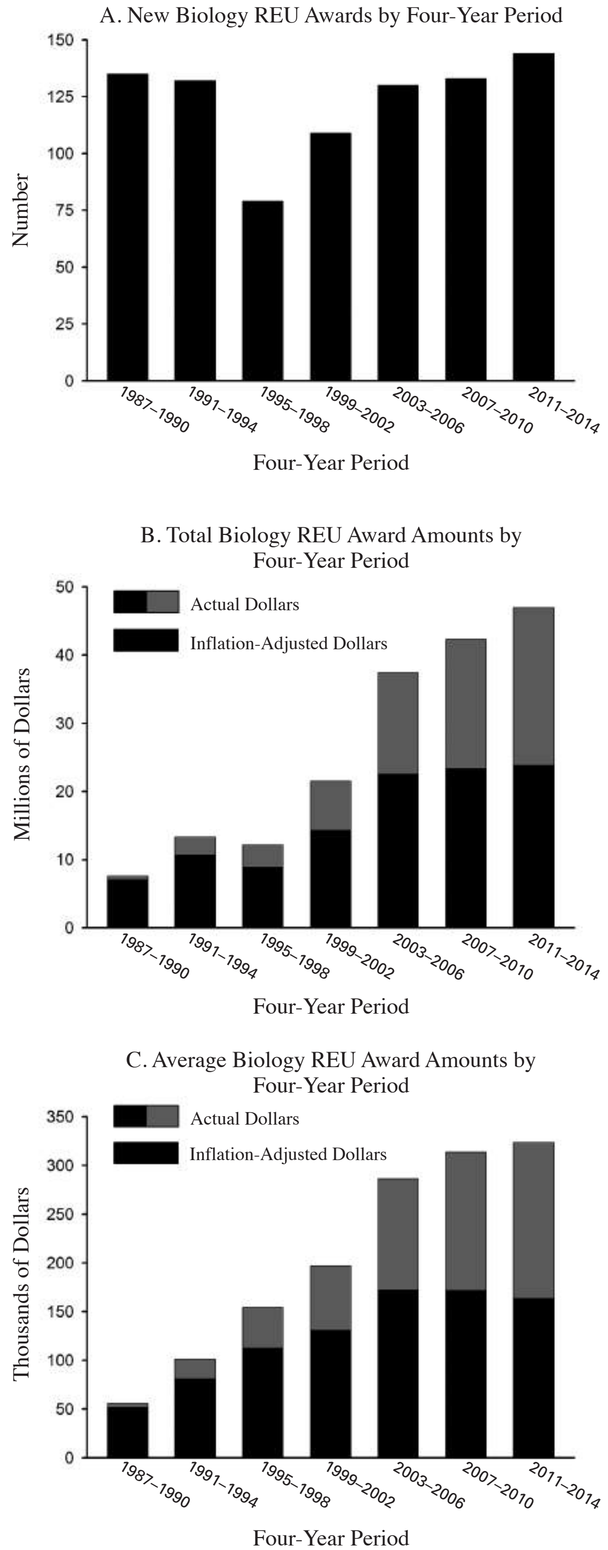
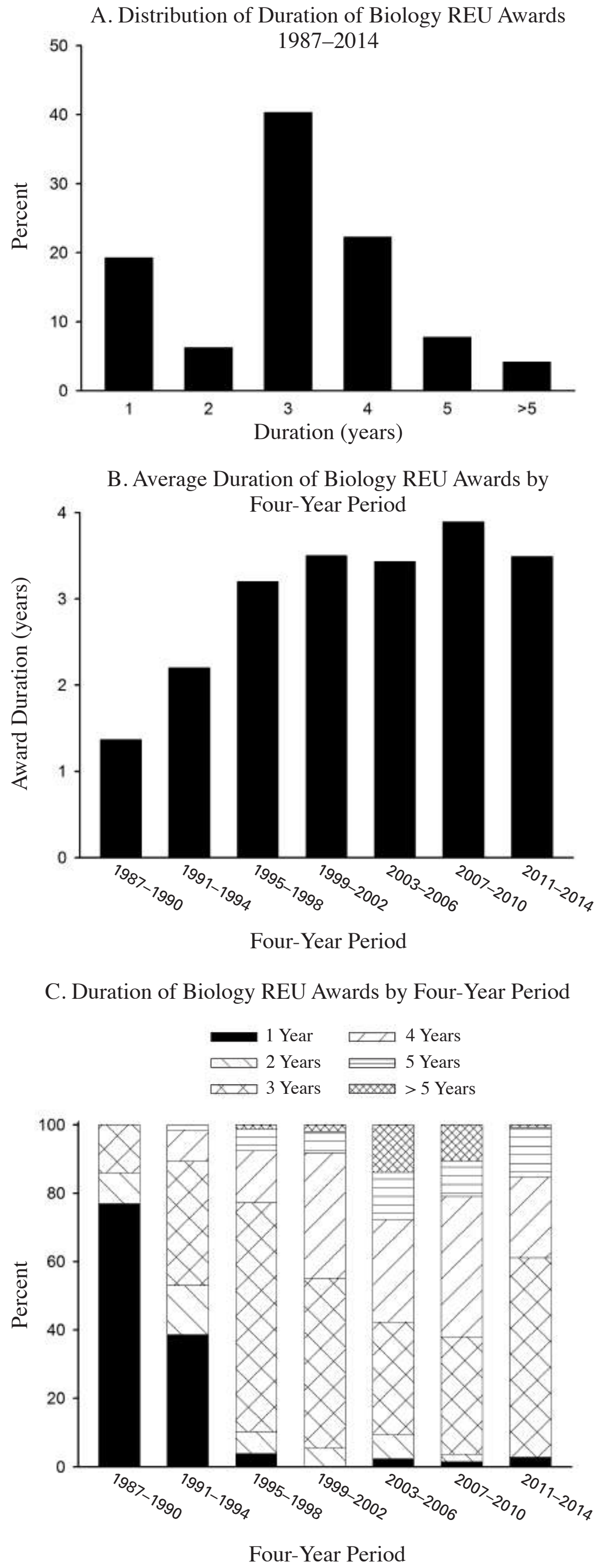


FIGURE 2. Durations of Biology REU Site Awards, 1987–2014



in 2011–2014. In inflation-adjusted dollars, the average award increased for the first five periods but then declined slightly for the last two periods. In inflation-adjusted dollars, the average award was approximately $46,000 in 1987–1990 and approximately $155,000 in 2011–2014. These increases reflect both the increased average duration of awards and the increased amount suggested per year per student in the NSF REU program solicitations.

Award Durations

Figure 2 provides data on the duration of awards. Award duration was determined by subtracting the award start dates from the award stop dates, dividing the resulting days by 365 to give years and then rounding the data into whole years with 0.50 values being rounded down. This was done to take into account the extra part of a year added by NSF to award duration primarily for reporting purposes. Award duration was also affected by programs that requested and received extensions of awards, so the reported durations may be greater than actual years of student support. The average duration of Biology REU Site awards from 1987 to 2014 was 3.06 years. Almost 75 percent of the awards were for three or more years (see Figure 2A). The average award duration increased from 1987–1990 to 1999–2002 and then leveled off with a small increase during 2007–2010. The distributions of durations of REU awards for each of the seven time periods are shown in Figure 2C. Whereas one-year awards were predominant from 1987–1990 when both the national REU program and individual sites were new, one-year awards declined to just a small percentage of the awards by 1995–1998. As the REU program matured, three- and four-year awards became the norm with relatively few awards lasting longer than four years. The distribution of durations of awards most likely reflects proposal requests and prior results, and may also reflect the balance attempted by NSF between providing stability in institutional REU Site programs and funding as many sites as possible. Multiplying the number of awards by the average duration of the award and by an estimate of the number of students supported each year by an award (10) gives an estimate of approximately 26,000 students supported by Biology REU Site awards.

Award Locations

Biology REU Site awards have been made to institutions in every state except for Wyoming and to institutions in Washington, DC, and Puerto Rico. Figure 3A shows how the number of awards has varied by location. More than half of the locations (32) have received 15 or fewer awards, and three locations have received more than 60 awards, with 15 locations receiving between 16 and 20 awards. Thus the identification of worthy Biology REU Site proposals throughout the country seems to have been achieved. Figure 4 shows the award distribution by location (Puerto Rico had seven awards). Award numbers were lowest in the Northwest, as well as parts of the South and New England. California, Massachusetts, and New York each had more than 60 awards.

FIGURE 3. Biology REU Site Awards by Location, 1987–2014

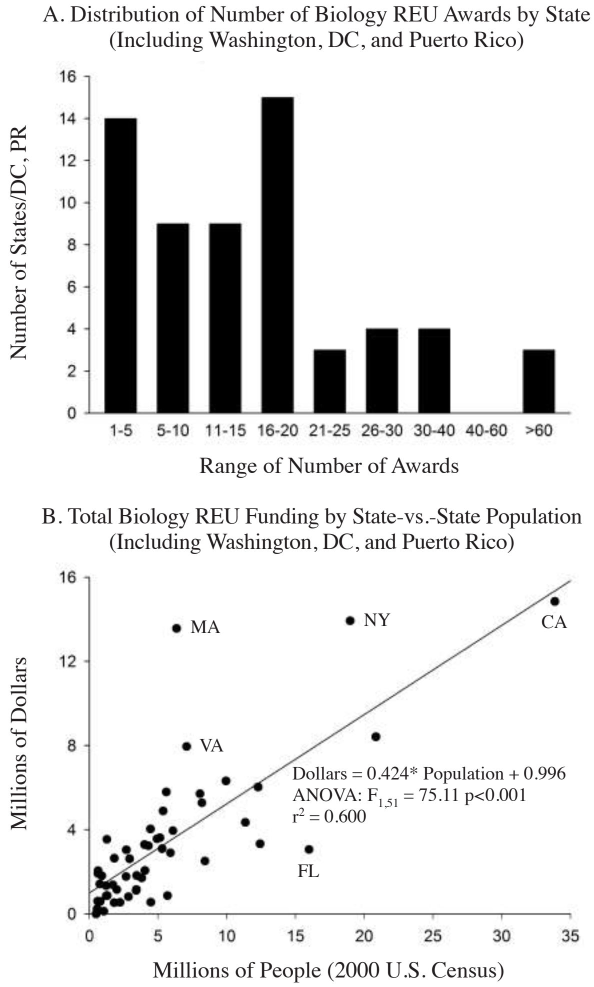


FIGURE 4. Distribution of Biology REU Site Awards, 1987–2014

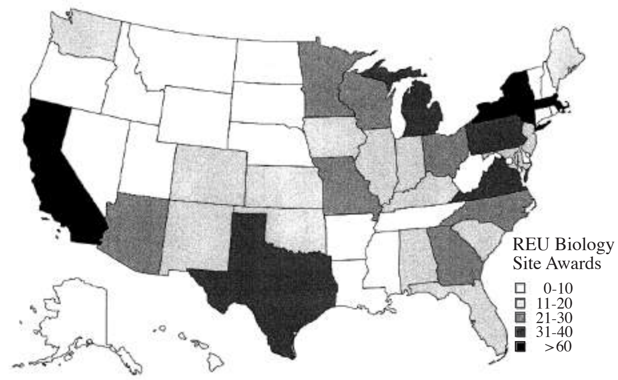
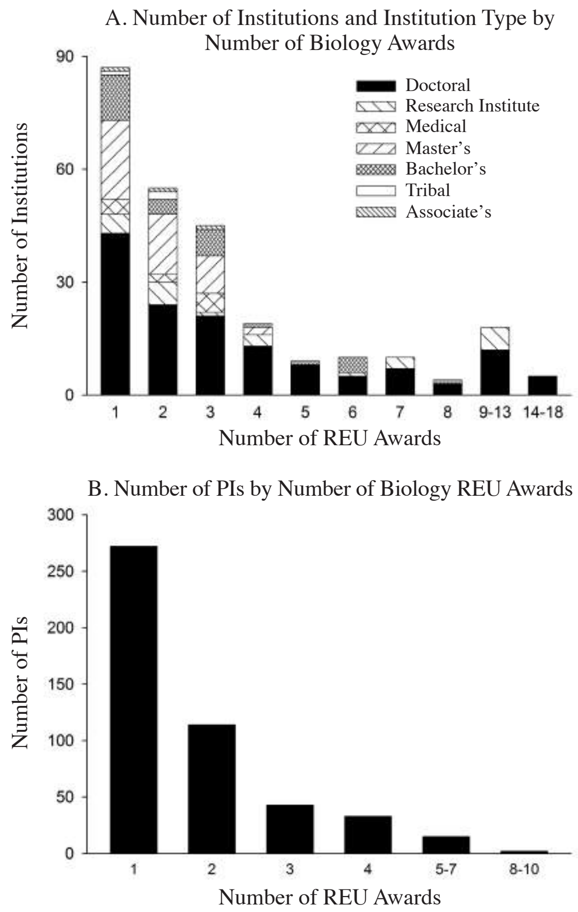


Figure 3B shows a regression analysis of the total funding between 1987 and 2014 by location versus location population as determined by the 2000 census (about halfway between 1987 and 2014; U.S. Bureau of the Census 2000). There is a highly significant ($p < 0.001$) relationship between population and total funding. Data points for California and four outlier states (Florida, Massachusetts, New York, and Virginia) are identified. The reasons for the outlier status of these four states are not entirely clear but no doubt reflect differences in proposal submission rates. Florida has the highest percentage of the population aged 65 or older, which may account partly for its lower level of Biology REU Site funding than would be predicted by its population. Massachusetts is the home of Harvard University, which had more Biology REU Site funding than any other institution (more than twice as much as the institutions ranked 15th and below in funding) and home of two other institutions in the top 10 percent of funding. New York is the home of numerous research institutes, and four of these were in the top 14 percent of funding with the Carey Institute of Ecosystem Studies present in the top 5 percent of funding. Virginia is the state of record of two institutions that were in the top 3 percent of funding, with one identified as the Smithsonian Institution.

FIGURE 5. Distribution of Number of Biology REU Site Awards by Institution and Principal Investigator, 1987–2014



Award Numbers by Institutions and Principal Investigators

Figure 5 shows the distributions of numbers of institutions (Figure 5A) and the numbers of PIs (Figure 5B) by total number of Biology REU Site awards held. Between 1987 and 2014, Biology REU Site awards were made to 257 different institutions. Of those, 87 institutions or 33.8 percent had only a single award (Figure 5A). Seventeen of the 87 institutions with a single award currently hold their first award, which means that 70 institutions either failed to reapply for a second award or failed to receive a second award after applying. The number of institutions in each category and the reasons for either of those two possibilities would be interesting to ascertain. Of the 257 institutions, 71 percent had three or fewer awards, and only 9 percent had nine or more awards. Because at least 10 percent of the institutions have had awards for different programs, relatively few institutions have been interested in maintaining or have been able to maintain a Biology REU Site program for very long. On the other hand, this means that more institutions have been awarded REU Site funds and have had a chance to carry out a program.

Some of the data were also analyzed based on the types of institutions receiving awards. For colleges and universities, the Carnegie Classification of Institutions of Higher Education at *About Carnegie Classification* (Indiana University 2015) was used, and then the institutions were clustered into six broad types (Carnegie Classifications): associate's (Assoc/Pub4), tribal (Tribal), bachelor's (Bac/A&S, Bac/Assoc, and Bac/Diverse), master's (Master's S, Master's M, and Master's L), medical (Spec/Med), and doctoral (DRU, RU/H, and RU/VH). One newer institution had not yet been categorized, but, based on the description of the institution at its website, it was categorized as a doctoral institution. Biology REU awards have also been made to non-academic institutions such as research institutes and government entities, and these were clustered together as research institutes. The number of awards per institution (Figure 5A) differed among the different types of institutions with only doctoral institutions and research institutes receiving more than six awards (with one exception).

There have been 480 different principal investigators (PIs) for the 863 Biology REU Site awards. Of these, 56.7 percent have received a single award (Figure 4B), and only 3.5 percent have received more than four awards. Thus, for many PIs, obtaining REU Site funding is a one-shot deal. Assuming there were no name duplications, 19 PIs have had awards at two or more institutions, including one PI who had awards at five different institutions. This demonstrates that some PIs have the ability to transfer their expertise in running a REU Site program to other institutions.

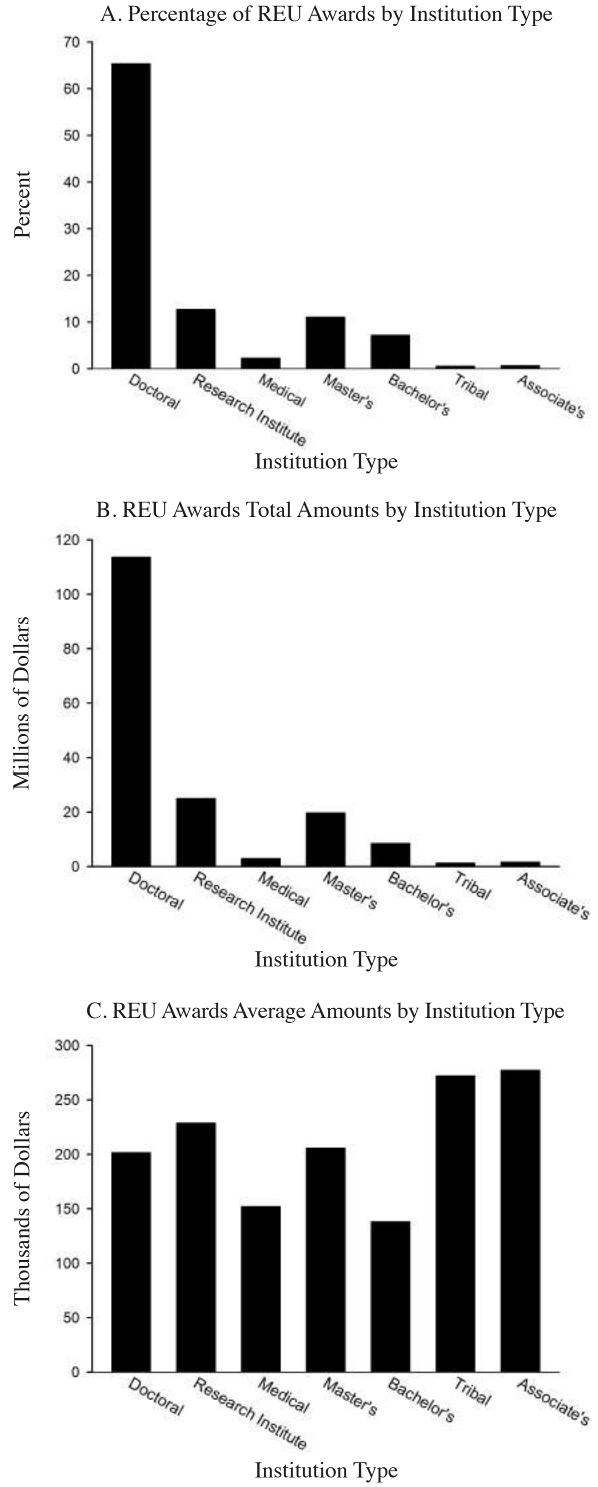
Of the 257 institutions with REU Site awards, 103 (40 percent) have had more than one PI for their awards. Thus there are a greater number of PIs than institutions receiving awards, which can be attributed to several causes. Some institutions have multiple REU programs, sometimes running concurrently. In some cases, the administration of an institution may select a new person to write and submit the proposal and direct the program, perhaps because the prior PI, who might be a staff person working as a director of undergraduate research, has left the position or institution. In many cases, however, it is also likely that the PI decided not to continue in that role. One factor in that decision may be a general lack of institutional reward for faculty in obtaining REU Site Award funding and directing the program. At many institutions, including Hope College, the award of funding for an REU Site does not carry with it the prestige and rewards (in terms of summer salary or merit raises) as does an NSF or NIH funding award for research. In most cases, the joys of interacting with outstanding undergraduates and the satisfaction of contributing to increasing the number and diversity of students who enter the STEM workforce are the primary rewards for the PI.

Award Type of Institution

From 1987 to 2014, a majority (65.5 percent) of the REU Site awards were made to doctoral institutions (Figure 6A). In descending order by percentage, awards were made to research institutes, master's institutions, bachelor's institutions, medical institutions, associate's institutions, and tribal colleges (Figure 6A). It would be of interest to learn from NSF if the difference in award numbers among types of institutions is a reflection of differences in numbers of proposals submitted, success rates of proposals, or both. The data for the total award amounts by institution type are shown in Figure 6B and are very similar to the data for percentage of awards for the various institution types, with the exception of the bachelor's institutions, which received 7.2 percent of the awards but only 5 percent of the funding. Figure 6C gives the average amount of funding per award for the seven different types of institutions. The higher levels for tribal colleges and associate's institutions may be attributable to inflation, as these institutions did not receive any awards during the first eight years of the program. Of the other types of institutions, research institutes had the highest average award amount at $229,000, and bachelor's institutions had the lowest award amounts at $138,000. These differences can be attributed to both differences in the average award duration (3.31 years for research institutes and 2.58 years for bachelor's institutions) and perhaps to smaller yearly numbers of REU students at bachelor's institutions.

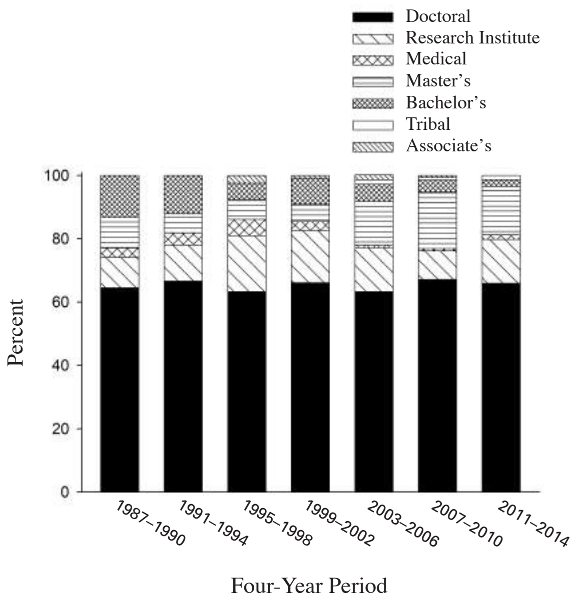
The way in which the distribution of awards to different types of institutions changed over the first 28 years of the NSF Biology REU program was also determined. As shown in Figure 7, the percentage of awards made to doctoral institutions has remained fairly steady when analyzed by four-year periods, with percentages varying from 63.3 percent to 67.2 percent. Medical institutions averaged 4.9 percent of the awards from 1987–2002, but only 1 percent of the awards from 2003–2014. No awards were made to associate's institutions during three of the seven periods, and the percentage averaged 1.4 percent during the other four periods. Tribal colleges only received awards during the last three periods, averaging 1.2 percent of the awards during those times. These awards reflect, in part, the efforts of NSF to encourage proposals from both

FIGURE 6. Distribution of Biology REU Site Awards by Institution Type, 1987–2014



associate's institutions and tribal colleges. The percentage of awards made to research institutes has varied from 9 percent to 17.7 percent during the four-year periods averaging 12.7 percent of all awards. During the first four years of the Biology REU program, 9.6 percent of the awards were made to master's institutions. This declined

FIGURE 7. Changes with Time in the Distribution of Biology REU Site Awards by Institution Type, 1987–2014



to an average of 6 percent of the awards from 1991–2002 but then more than rebounded such that master's institutions received an average of 15.7 percent of the awards from 2003–2014.

The institutional group that has shown the largest, fairly steady decline in the percentage of awards obtained is the bachelor's institutions. During the first four years of the program, bachelor's institutions received 13.3 percent of the awards, but from 2011 to 2014, they only received 2.1 percent of the awards. It is not entirely clear why the overall award percentage to bachelor's institutions has declined so much. One hypothesis is that, at some point, increased percentages of proposals from bachelor's institutions were not awarded funds and this led to general discouragement and a reduction in the number of proposals submitted from bachelor's institutions. Information from NSF about the number of proposals and the success rate of proposals from bachelor's institutions specifically and/or a survey of past and present PIs at bachelor's institutions would be of interest in this regard. It would also be of interest to determine if there has been a change in philosophy regarding the Biology REU site program at NSF or by the REU Site grant proposal reviewers. Alternatively, it is possible that PIs at bachelor's institutions have turned to other NSF grant programs to support undergraduate research, although a search of the NSF grant website for research awards to undergraduate institutions indicated that the number of such awards has been relatively stable from 1987 to 2014. Another possibility is that PIs at bachelor's institutions have decided that the requirement for a high percentage of REU participants to come from outside their institutions has made the program less attractive to faculty participants and the institutions.

Summary and Conclusions

Since 1987, the National Science Foundation has supported the involvement of thousands of undergraduate students in research in biology through Biology REU Site awards. From 1987 to 2014, there was an average of 30.8 new REU Site awards per year with an average duration of three years. Total funding for Biology REU Site awards has increased for each four-year period analyzed since 1995–1998 in actual dollars but not increased substantially in inflation-adjusted dollars since the 2003–2006 analysis period. Average award funding in inflation-adjusted dollars increased from 1987–1990 to 2003–2006, which reflects the increased duration awards, and then declined slightly for the 2007–2010 and 2011–2013 periods. Awards have been made to institutions in every state except Wyoming as well as to institutions in Washington, DC, and Puerto Rico. The total Biology REU Site funding per state/location is highly correlated with the state/location population, with the exceptions of Virginia, Massachusetts, and New York, which had higher than predicted funding levels, and Florida, which had a lower than predicted funding level. Awards have been made to 257 institutions and 480 PIs. Many institutions (33.8 percent) and PIs (56.7 percent) have had only one Biology REU Site award, and 10.5 percent of the institutions and 3.5 percent of the PIs have had five or more awards. Doctoral institutions have had the largest percentage of awards (65.5 percent) followed by research institutes, master's institutions, bachelor's institutions, medical institutions, associate's institutions, and tribal colleges. From 1987–1990 to 2011–2014, the percentage of the awards made to master's institutions increased from 9.6 percent to 15.3 percent, and the percentage of awards made to bachelor's institutions decreased from 13.3 percent to 2.1 percent.

Acknowledgments

The author thanks Jacqueline DeBoard for assisting with the data analysis and Leah Chase for reviewing this article and providing valuable advice.

References

American Association for the Advancement of Science (AAAS). 2016. "Historical Trends in Federal R&D." Accessed August 1, 2016. http://www.aaas.org/page/historical-trends-federal-rd.

Beninson, Lida A., Jessica Koski, Erika Villa, Ronnie Faram, and Sally E. O'Connor. 2011. "Evaluation of the Research Experiences for Undergraduates (REU) Sites Program." *CUR Quarterly* 32(1): 43–48.

Doyle, Michael P. 1987. "Editorial Comments: The New NSF-REU Program Is Not the Return of the URP Program." *CUR Newsletter* 7(2): 3–4.

Eagan, M. Kevin Jr., Sylvia Hurtado, Mitchell J. Chang, Gina A. Garcia, Felisha A. Herrera, and Juan C. Garibay. 2013. "Making a Difference in Science Education: The Impact of Undergraduate Research Programs." *American Educational Research Journal* 50: 683–713. doi: 10.3102/0002831213482038

Economy, D. Ross, Julia L. Sharp, Julie P. Martin, and Marian S. Kennedy. 2014. "Factors Associated with Student Decision-Making for Participation in the Research Experiences for Undergraduates Program." *International Journal of Engineering Education* 30(6A): 1395–1404.

Hunter, Anne-Barrie, Timothy J. Weston, Sandra L. Laursen, and Heather Thiry. 2009. "URSSA: Evaluating Student Gains from Undergraduate Research in the Sciences." *CUR Quarterly* 29(3): 15–19.

Indiana University. Center for Postsecondary Research. *About Carnegie Classification*. 2015. Accessed November 5–21, 2015. http://carnegieclassifications.iu.edu/

Lopatto, David. 2004. "Survey of Undergraduate Research Experiences (SURE): First Findings." *Cell Biology Education* 3: 270–277. doi: 10.1187/cbe.04-07-0045

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

Lopatto, David. 2009. *Science in Solution: The Impact of Undergraduate Research on Student Learning*. Washington, DC: Council on Undergraduate Research. Tucson: Research Corporation for Science Advancement.

National Science Foundation (NSF). Program Evaluation Staff. 1990. *NSF's Research Experiences for Undergraduates (REU) Program: An Assessment of the First Three Years*. Washington, DC: Author.

Neckers, Douglas C. 1982. "The Threat to Undergraduate Research." *Journal of Chemical Education* 59: 328–329. doi: 10.1021/ed059p329

O'Connor, Sally E. 2014. *Bio REU PI Workshop NSF Presentation*. Accessed February 8, 2016. http://www.bioreu.org/downloads/2014_REU_PI_Mtg_OConnor.pdf

Russell, Susan H. 2006. *Evaluation of NSF Support for Undergraduate Research Opportunities: Synthesis Report*. Menlo Park, CA: SRI International. Accessed February 3, 2016. http://csted.sri.com/content/evaluation-nsf-support-undergraduate-research-opportunities-uro-synthesis-report

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

Schmitz, Heather Johnson, and Karen Havholm. 2015. "Undergraduate Research and Alumni: Perspectives on Learning Gains and Post-graduation Benefits." *CUR Quarterly* 35(3): 15–22.

Seymour, Elaine, Anne-Barrie Hunter, Sandra L. Laursen, and Tracee 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

Thiry, Heather, Timothy J. Weston, Sandra L. Laursen, and Anne-Barrie Hunter. 2012. "The Benefits of Multi-Year Research Experiences: Differences in Novice and Experienced Students' Reported Gains from Undergraduate Research." *CBE–Life Sciences Education* 11: 260–272. doi: 10.1187/cbe.11-11-0098

U.S. Bureau of the Census. 2000. Accessed February 4, 2016. https://www.census.gov/population/www/cen2000/maps/respop.html

U.S. Department of Labor. Bureau of Labor Statistics. 2016. CPI Inflation Calculator. Accessed February 2, 2016. http://data.bls.gov/cgi-bin/cpicalc.pl

Yaffe, Kirsten, Carol Bender, and Lee Sechrest. 2014. "How Does Undergraduate Research Experience Impact Career Trajectories and Level of Career Satisfaction: A Comparative Survey." *Journal of College Science Teaching* 44(1): 25–33. doi: 10.2505/4/jcst14_044_01_25

Christopher C. Barney
Hope College, barney@hope.edu

Christopher C. Barney is the T. Elliot Weier Professor of Biology at Hope College, where he has been a member of the faculty for 36 years. He has served as the chair of the Biology Department and the faculty moderator at Hope and as a member of the Education Committee of the American Physiological Society. He also served as the PI or co-PI of seven NSF REU awards and as the director of Hope's HHMI program. He and the undergraduate students in his lab do research in the areas of thirst and water balance, as well as the regulation of metabolic rate, body temperature, and blood pressure.

ASSESSMENT

Student Outcomes from Undergraduate Research Programs: Comparing Models of Research Experiences for Undergraduates (REUs)

D. Jake Follmer, Sarah Zappe, Esther Gomez, Manish Kumar,
Pennsylvania State University

Abstract

Programs involving research experiences for undergraduates (REUs) typically reflect either university-sponsored programs or programs funded by the National Science Foundation (NSF) that aim to facilitate students' research-based skill development. Despite the prevalence of research supporting the effectiveness of these programs, little research has compared the programs or evaluated the impact of differing REU models on gains in student research skills. This article examines gains made in research-based skills and experiences by students who participated in a university-sponsored or an NSF-funded REU program in engineering at a large research university. Students completed measures of research-based experiences, openness to research collaboration, and likelihood of pursuing graduate school activities prior to and after completing the research programs. Students also rated the effectiveness of core REU elements at program completion. Students participating in both REU programs demonstrated significant gains in a measure of research-based experience. Students participating in the NSF-funded REU reported higher gains in specific research-based skills compared with students participating in the university-sponsored REU. Student ratings of the openness to research collaboration and likelihood of pursuing graduate school were comparable across REU programs.

Keywords: *undergraduate research, STEM, underrepresented groups, REU programs, assessment, program evaluation*

doi: 10.18833/spur/1/1/5

Research programs that provide research-based experiences for undergraduate students in science, technology, engineering, and mathematics (STEM) areas have demonstrated a number of benefits, including increases in students' research skills, ability to collaborate when conducting research, and ability to communicate research-based findings (Bielefeldt 2012; Guerrero, Labrador, and Pérez 2007; Hsieh 2013; Kardash 2000; Lopatto 2007). Undergraduate research programs typically reflect either NSF-funded research experiences for undergraduates (REU) models or comparable REU models sponsored by the university. Despite programmatic differences between the research programs, the overarching goals, intent, and structure of the programs are often similar (Sheng, Landers, and Nguyen 2014; Sutterer et al. 2005; Zydney et al. 2002a). A direct comparison of student research-based experiences and gains based on the type of REU program implemented, however, has not yet been conducted. The primary goal of this research was to examine differences in gains in research-based experiences made by students who participated in an NSF-funded program compared with a university-sponsored REU program.

In a review of the literature, Seymour and colleagues reviewed published studies and conference proceedings examining the impact of undergraduate research experiences on student outcomes (Seymour et al. 2004). Based on their assessment, they clustered the most commonly indicated benefits to students of such programs. These included increased interest in specific areas of research; increased recruitment of underrepresented groups in research-based experiences; increased understanding of the research process; gains in research and research-based skills; and clarification, refinement, and confirmation of educational- and career-related goals (Seymour et al. 2004). In an evaluation of undergraduate research experiences, Zydney and colleagues found that students who participated in undergraduate research described the experience as very important to their educational experiences; students who engaged in research experiences for longer periods of time also indicated greater perceived benefit of research experiences (Zydney et al. 2002b). Undergraduate students with research experience have also indicated greater development of the ability to understand scientific findings, communicate the results of research effectively, and understand and analyze research literature accurately (Lopatto 2007; Willis, Krueger, and Kendrick 2009; Zydney et al. 2002b).

Benefits and Drawbacks to the REU Models

NSF-funded REU models have demonstrated a host of advantages that facilitate increases in research skills among participating students (Lopatto 2007; Minerick 2008; Sheng et al. 2014; Willis et al. 2009). For example, diverse groups of students from various institutions and backgrounds are able to participate in rigorous research experiences that may not otherwise be accessible at their home institutions (Goldberg et al. 2011; Lopatto 2007; Seymour et al. 2004). In addition, programs are typically thematically defined at the outset with respect to research aims and foci. Such a structure facilitates clear research-based expectations for participating students. However, there is a period of adjustment and adaptation for student participants needed at program initiation due to relocation to the home institution. This, combined with the rigid time frame (10 weeks), often does not allow for extended engagement with research beyond the length of the program. Because of the nature of the program funding, NSF-funded programs also typically consist of smaller numbers of students.

With respect to university-sponsored REU programs, participating students often work with investigators with whom they have familiarity or experience, facilitating the potential continuity of research engagement after REU program completion (Zydney et al. 2002a). As a function of participating students residing at the host institutions, less time for adjustment to the university and to the REU program is often required. However, the programs typically tend to have a less diverse participant group when compared to NSF-funded programs. Finally, because of the breadth and size of university-sponsored REUs, participating students are more likely to conduct research projects on varied topic areas during the course of the REU program.

Description of the REU Models

The NSF-funded REU program investigated in this study was housed at a large, midatlantic research university and utilized a 10-week program schedule. The program centered on chemical engineering and the integration of biology and materials with a focus on allowing undergraduate students to engage in research in the area of biomolecular materials. Program requirements included the completion of research summaries and overviews as well as poster and oral presentations held at a program-sponsored REU symposium. Orientation sessions were held at the outset of the program that served the functions of acclimating participants to the host institution as well as to the research and laboratory environments, providing training on laboratory procedures, and providing training on safety and safety-related procedures in the laboratory setting.

The university-sponsored REU was held at the same research university as the NSF-funded REU and reflected an eight-week undergraduate research program. Program requirements included the submission of research papers and culminated in presentations held at a program-sponsored REU symposium. Across both REU programs, students were provided with professional development workshops that targeted a variety of research-based skills, including technical writing, presentation skills, and information about graduate school and pursuing a graduate degree. Social events were also embedded into the program structure to facilitate integration and foster a sense of research community among students. Thus, there was commonality in the structure and requirements of the programs that allowed for direct comparison of gains made by participating students.

The Current Study

The primary goal of the current study was to examine gains made by students participating in either an NSF-funded or a university-sponsored REU program. Based on a search in the literature, a direct comparison of the impact of differing REU models on students' research-based experiences and gains has not been conducted. In support of the research aims, the following research question guided the current study:

> Are there differences in gains in research-based experience, openness to collaboration, and likelihood of pursuing graduate school by students participating in an NSF-funded compared with a university-sponsored REU program?

Method

Participants. Demographic information for participants in both REU programs is included in Table 1. To facilitate the comparison of gains with the university-sponsored REU program, students participating in the NSF-funded REU were pooled across years 1 and 2 of the program. Across REU programs, the percentage of students who were female and from underrepresented groups exceeded the typical representation of such students at the bachelor's degree level in engineering overall (Yoder 2013). The NSF-funded REU program enrolled a higher percentage of underrepresented students than the university-sponsored REU program. One of the overarching goals of the NSF-funded program is to enroll underrepresented students. The number of students with previous research experience was small (i.e., 3) across research programs. However, the analyses employed controlled for presurvey scores on both measures of research experience, thus reducing the potential for confounding based on students' previous experience with research.

Measures and Procedure. Descriptions of assessment outcomes, timing of administration for assessments, and assessment procedures are included in Table 2. The same assessment methodology was employed for both REU programs to facilitate the evaluation of post-REU gains. Measures administered during the presurvey and postsurveys are described in Table 3. Institutional Review Board (IRB) approval was obtained prior to data collection; implied consent was obtained prior to data collection for the presurvey and postsurvey administrations.

Participants were administered two scales designed to measure experience with research and research-based skills. The first scale, the Undergraduate Research Student Self-Assessment (URSSA), is an NSF-funded survey instrument designed to measure student learning gains from undergraduate research experiences in specific research-based areas, such as skills related to lab work and communication of research findings (Weston and Laursen 2015). To assess broad experience with research, the Experience with Research Activities Scale (EWRAS) was designed by the authors for the assessment of the current NSF-funded REU (Follmer et al. 2016). The EWRAS measured participants' reported experience with research, experience working in a research lab, and experience collaborating with faculty and students in research settings. In this way, the measures allowed for the assessment of both broad (i.e., overall) and specific research-based experiences and skills applied to engineering-based research. Prior research has provided validity evidence supporting score interpretations for both measures (Follmer et al. 2015; Weston and Laursen 2015). Scores on both the presurvey and postsurvey administrations of the URSSA and EWRAS demonstrated adequate reliability based on calculation of Cronbach's alpha values ranging from 0.79 to 0.96.

Participants also completed items measuring openness to collaborating with other students while engaged in research activities, likelihood of pursuing graduate school, and ratings of program elements (e.g., working relationship with mentors; amount of time spent doing meaningful research). Finally, at the completion of the postsurvey, participants rated their overall satisfaction with the REU programs and indicated their educational- or career-related plans and goals after graduation.

TABLE 1. Demographic Information of Participants across REU Models

REU model	Number of participants	% Past REU experience	% Female	% URM	% Fr/So/Ju/Se
NSF-funded REU	22	14	36	59	0/32/50/18
University-sponsored REU	45	7	36	20	15/40/38/7

Note: URM=Underrepresented minority; Fr=Freshmen; So=Sophomore; Ju=Junior; Se=Senior.

TABLE 2. Assessment Measures and Procedure

Instrument	Outcomes measured	Time of administration	Assessment procedures
Presurvey	Prior REU participation; prior experience with research; openness to collaborating; likelihood of graduate school	NSF-funded REU: Week 1 (of 10) University-sponsored REU: Week 1 (of 8)	Administered via online survey software
Postsurvey	Experience with research; openness to collaborating; likelihood of graduate school; ratings of REU experiences; satisfaction with REU; initial career/graduate school plans	NSF-funded REU: Week 10 (of 10) University-sponsored REU: Week 8 (of 8)	Administered via online survey software

TABLE 3. Description of Presurvey and Postsurvey Measures

Measure	Number of items	Scale type	Scale anchors	Timing of administration
URSSA	37	6-Point Likert	Not at all confident–Very confident	Presurvey and postsurvey
EWRAS	4	5-Point Likert	Not experienced–Very experienced	Presurvey and postsurvey
Openness to collaboration	1	5-Point Likert	Not open–Very open	Presurvey and postsurvey
Likelihood of graduate school	1	5-Point Likert	Very unlikely–Very likely	Presurvey and postsurvey
Ratings of core REU experiences	6	5-Point Likert	Poor–Excellent	Postsurvey
Satisfaction	1	5-Point Likert	Very dissatisfied–Very satisfied	Postsurvey
Educational or career plans	2	4-Point Likert Open-ended	Graduate school, master's; Graduate school, doctorate; Career, engineering; Graduate school and career, engineering; other	Postsurvey

Note: URSSA=Undergraduate Research Student Self-Assessment; EWRAS=Experience with Research Activities Scale

Results

Preliminary Analyses. Descriptive statistics for presurvey and postsurvey measures are included in Table 4. Scores on the URSSA and EWRAS were comparable across gender and ethnicity. To ensure that the findings presented were not impacted by examining data from participants across the two years of the NSF-funded REU program, differences in postsurvey scores were examined. Differences in students' scores between years of the NSF-funded REU were not observed for the URSSA, $t = 1.40$, $p > .05$, or the EWRAS, $t = 0.16$, $p > .05$.

Scores on the URSSA were moderately correlated with scores on the EWRAS, $r = 0.26$, $p < .05$, indicating convergence between the presurvey measures but also that the scales measured distinct aspects of participants' prior research-based experiences. A one-way MANOVA was conducted to examine differences in participating students' reported research experience at presurvey. Significant differences in presurvey measures based on REU type were not obtained, $\lambda = 0.87$, $F\ (4, 58) = 2.15$, $p > .05$, suggesting that participating students were comparable in their reported pre-REU research experience. Because the number of students indicating prior experience with research was small, inferential tests examining differences in gain scores based on prior experience could not be performed.

Scores on the postsurvey administration of the URSSA and EWRAS were again comparable across gender and ethnicity. As with the presurvey, scores on the postsurvey administrations of the URSSA and EWRAS were moderately correlated, $r = 0.30$, $p < .05$, suggesting that the measures were related but tapped distinct aspects of participants' research-based skills and experiences.

Examination of Within-Group Gains and Program Ratings

Examination of the University-Sponsored REU. Students who participated in the university-sponsored REU program demonstrated a significant increase in broad research-based experience as measured by the EWRAS, $F\ (1, 24) = 37.23$, $p < .05$, $\eta_p^2 = 0.61$. Descriptively, students demonstrated a mean increase in EWRAS scores from presurvey ($M = 10.27$) to postsurvey ($M = 14.28$). No statistically significant difference in URSSA scores was obtained, $F\ (1, 24) = 0.01$, $p > .05$. Students indicated satisfaction with the REU program as well as positive ratings of program elements. Participants rated themselves as being satisfied overall with the program ($M = 4.14$). Ratings of "Good" or higher were indicated for the following REU elements: working relationship with research mentors ($M = 3.34$; $Mo = 4$), working relationship with research group members ($M = 3.07$; $Mo = 4$), and the research experience overall ($M = 3.21$; $Mo = 4$). Ratings for the following areas received "Fair" to "Good" ratings: the amount of time spent doing meaningful research ($M = 2.76$; $Mo = 3$), the amount of time spent with research mentor(s) ($M = 2.93$; $Mo = 3$), and the advice provided by research mentor(s) about careers or graduate school ($M = 2.90$; $Mo = 3$).

TABLE 4. Descriptive Statistics for Presurvey and Postsurvey Measures

Measure	Mean	Median	Standard deviation	Minimum–maximum
Presurvey				
URSSA				
NSF-funded REU	153.93	154.00	25.76	112.00–218.00
University-sponsored REU	163.02	160.00	24.58	117.00–219.00
EWRAS				
NSF-funded REU	12.18	12.00	4.64	4.00–19.00
University-sponsored REU	10.27	9.00	4.68	4.00–18.00
Openness to collaborating				
NSF-funded REU	4.68	5.00	0.48	4.00–5.00
University-sponsored REU	4.56	5.00	0.67	2.00–5.00
Likelihood of graduate school				
NSF-funded REU	4.05	4.00	0.95	2.00–5.00
University-sponsored REU	3.71	4.00	1.01	2.00–5.00
Postsurvey				
URSSA				
NSF-funded REU	176.38[ab]	169.50	18.34	149.00–213.00
University-sponsored REU	162.88	159.00	28.90	112.00–221.00
EWRAS				
NSF-funded REU	15.81[a]	16.00	2.54	12.00–20.00
University-sponsored REU	14.28[a]	15.00	2.88	8.00–20.00
Openness to collaborating				
NSF-funded REU	4.63	5.00	0.50	4.00–5.00
University-sponsored REU	4.56	5.00	0.71	2.00–5.00
Likelihood of graduate school				
NSF-funded REU	4.06	4.00	1.00	2.00–5.00
University-sponsored REU	3.60	4.00	1.12	1.00–5.00

Note: URSSA=Undergraduate Research Student Self-Assessment; EWRAS=Experience with Research Activities Scale
[a]A statistically significant increase in mean scores from pressurvey to postsurvey was obtained.
[b]A statistically significant difference in mean scores between REU programs was obtained.

Students' specific career or graduate school plans were assessed during the postsurvey only. Approximately 31 percent of university-sponsored REU students indicated plans to pursue a master's degree, 17 percent indicated plans to pursue a doctoral degree, and 21 percent indicated plans to pursue graduate school concurrent with a career in engineering. Thus, taken together, approximately 69 percent of participants indicated plans for some level of graduate school. Finally, 28 percent of participants indicated plans for pursuing a career in engineering after graduation. Several students were undecided about their plans after graduation.

Examination of the NSF-Funded REU. Students who participated in the NSF-funded REU program demonstrated significant gains in broad research experience as measured by the EWRAS, F (1, 16) = 8.05, $p < .05$, $\eta_p^2 = 0.34$. A significant gain in URSSA scores was also obtained, F (1, 15) = 27.76, $p < .05$, $\eta_p^2 = 0.65$, indicating increases in specific research-based experiences among students. Descriptively, participating students demonstrated an increase in mean scores on the EWRAS from 12.18 to 15.81 and from 153.93 to 176.38 on the URSSA as noted in Table 4. Taken together, the findings indicated significant gains in both broad research experience and specific research skills among students participating in the NSF-funded REU.

Students likewise indicated satisfaction with the REU program (M = 4.17; Mo = 4). Ratings of "Good" or higher were obtained for the following REU elements: working relationship with research mentor(s) (M = 3.17; Mo = 4), working relationship with research group members (M = 3.75; Mo = 4), the advice given about careers and graduate school (M = 3.45; Mo = 3), and the research experience overall (M = 3.25; Mo = 3). The REU elements of the amount of time spent doing meaningful research (M = 2.83; Mo = 2) and the amount of time spent with research mentor(s) (M = 2.83; Mo = 4) received a "Fair" rating, suggesting areas for improvement in the program. With regard to specific career and graduate school plans (assessed during the postsurvey only), approximately 8 percent of NSF-funded REU students indicated plans for pursuing a master's degree, whereas 50 percent of students indicated plans for pursuing a doctoral degree. Thus, approximately 58 percent of participants indicated plans for some level of graduate school after graduation. Finally, approximately 33 percent of students expressed plans for pursuing a career in industry.

Comparison of Gains between REU Programs. To examine differences in gains made by students based on participation in either the university-sponsored or the NSF-funded REU, analysis of covariance (ANCOVA) was used to control for scores on the presurvey measures of research experience. The analysis was based on adjusted means; these adjusted means differ slightly from the mean values reported in Table 4. ANCOVA revealed a statistically significant difference in URSSA scores by REU type, F (1, 38) = 6.72, $p < .05$, $\eta_p^2 = 0.15$, controlling for presurvey URSSA scores. The analysis indicated significantly higher scores on the URSSA at program end for students participating in the NSF-funded REU (adjusted M = 180.71) compared with the university-sponsored REU (adjusted M = 160.11). Significant differences were not obtained on scores on the EWRAS, F (1, 39) = 0.62, $p > .05$, $\eta_p^2 = 0.02$, after controlling for presurvey EWRAS scores (adjusted M = 15.28 and 14.69 for the NSF- and university-sponsored REUs respectively).

Students' openness to collaboration with others and reported likelihood of pursing graduate school were assessed at both presurvey and postsurvey. To examine gains in students' openness to collaboration and likelihood of pursuing graduate school, gain scores were computed to capture increases in students' ratings from presurvey to postsurvey. Significant differences in gain scores were not observed for either openness to collaboration, $t = 0.25$, $p > .05$, or likelihood of pursuing graduate school, $t = 0.56$, $p > .05$, suggesting that students entered and completed the programs comparably in terms of their openness to collaborating with others and likelihood of pursuing graduate school. More students in the university-sponsored REU indicated plans of pursuing graduate school overall (69 percent); however, more students in the NSF-funded REU indicated plans for specifically pursuing a doctoral degree (50 percent).

Conclusions

The findings overall support the use of undergraduate research programs to facilitate student gains in research-based skills and experience (Bielefeldt 2012; Kardash 2000; Pariyothorn and Autenrieth 2012; Willis et al. 2009). Students participating in both the NSF-funded and the university-sponsored REU programs experienced significant increases in a measure of broad research experience. Across REU programs, students rated themselves as open to collaborating with others while conducting research both before and after the research programs. Likewise, student ratings of the likelihood of pursuing graduate school were comparable across REU programs, although descriptive differences in the type of graduate degrees to be pursued by REU students were obtained. These findings suggest that structured research experiences increase students' perceptions of their overall research experience comparably. They also suggest that most students who report plans for graduate education continue to do so after completing the research programs. Such findings support previous claims by Seymour and colleagues (2004) that undergraduate research experiences serve to clarify and refine students' decisions to choose a graduate school career path rather than prompt them to do so (Follmer et al. 2015).

In comparing gains between research programs, NSF-funded REU students reported higher gains in specific research-based skills, as measured by the URSSA, than university-sponsored REU students. This finding could be attributed to two differences between the REU programs. First, the NSF-funded REU program lasted approximately two weeks longer than the university-sponsored program, suggesting that students' gains relative to those participating in the university-sponsored REU may have been based on the increased exposure to and experience with specific research skills and techniques. Second, the NSF-funded REU strongly emphasized collaboration between student participants completing the research projects from different universities. This collaboration occurred between undergraduate students enrolled at the host institution (but distinct from those students participating in the university-sponsored program) and students participating in the program from outside institutions. It is possible that this collaborative experience resulted in increased gains in research-based skills relative to students who participated in the university-sponsored program. Thus, students may derive benefit from the ability to collaborate with others, including other undergraduate research participants and graduate student mentors, while conducting research and completing research requirements.

The examination of research experiences of REU students would likely be improved in two ways. First, future research should examine whether students participating in university-sponsored REU programs benefit from long-term effects as a result of their continued work on the same or similar research projects. Second, future research should also examine whether university-based students benefit from sustained mentorship from faculty advisers and whether this benefit yields increases in research skills and experiences. The aim of the current study was to directly examine gains made by students participating in both REU programs after program completion. Longitudinal comparisons are ongoing, and such analyses may provide additional information about student benefits from research programs.

References

Bielefeldt, Angela. 2012. "Student Learning Outcomes from an Environmental Engineering Research Program." *Proceedings, American Society for Engineering Education*, 1–21. San Antonio, TX.

Follmer, D. Jake, Sarah E. Zappe, Manish Kumar, and Esther Gomez. 2015. "Preliminary Evaluation of a Research Experience for Undergraduates (REU) Program: A Methodology for Examining Student Outcomes." *Proceedings, American Society for Engineering Education*, 1–30. Seattle, WA. doi: 10.18260/p.24580

Follmer, D. Jake, Sarah E. Zappe, Manish Kumar, and Esther Gomez. 2016. "Examining Student Outcomes from a Research Experiences for Undergraduates (REU) Program: Year Two Results." *Proceedings, American Society for Engineering Education*, 1–13. New Orleans, LA. doi: 10.18260/p.26793

Goldberg, Mary R., Rory A. Cooper, Dan Ding, and Alicia Koontz. 2011. "Using Experiential Learning to Inspire, Educate, and Empower Underrepresented Undergraduates in STEM." *Proceedings, American Society for Engineering Education,* 1–18. Vancouver, Canada.

Guerrero, Cesar D., Miguel A. Labrador, and Rafael A. Pérez. 2007. "Graduate Students Mentors in REU Sites." *Proceedings, American Society for Engineering Education*, 1–13. Honolulu, HI.

Hsieh, Sheng-Jen. 2013. "Research Experiences for Undergraduate Engineering Students." *Proceedings, American Society for Engineering Education*, 1–13. Atlanta, GA.

Kardash, CarolAnne M. 2000. "Evaluation of Undergraduate Research Experience: Perceptions of Undergraduate Interns and Their Faculty Mentors." *Journal of Educational Psychology* 92: 191–201. doi: 10.1037//0022-0663.92.1.191

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

Minerick, Adrienne R. 2008. "NSF REU Site: Chemistry/Chemical Engineering: The Bonds between Us—A Three Year Retrospective." *Proceedings, American Society for Engineering Education*, 1–13. Pittsburgh, PA.

Pariyothorn, Matthew, and Robin L. Autenrieth. 2012. "Strategic Use of Summer Undergraduate Research Experiences." *Proceedings, American Society for Engineering Education*, 1–13. San Antonio, TX.

Seymour, Elaine, Anne-Barrie Hunter, Sandra L. Laursen, and Tracee DeAntoni. 2004. "Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-Year Study." *Science Education* 88: 493–534. doi: 10.1002/sce.10131

Sheng, Hong, Robert Landers, and Thanh Nguyen. 2014. "A Longitudinal Study on the Effectiveness of the Research Experience for Undergraduates (REU) Program at Missouri University of Science and Technology." *Proceedings, American Society for Engineering Education*, 1–21. Indianapolis, IN.

Sutterer, Kevin, Martin Brenny, David J. Pirnia, Michelle Woodward, Robert Houghtalen, and Jim Hanson. 2005. "Engineering REU Sites: Designing for Appropriate and Valuable Summer Educational Experiences." *Proceedings, American Society for Engineering Education*, 1–12. Seattle, WA.

Undergraduate Research Student Self-Assessment (URSSA). 2009. Ethnography & Evaluation Research, University of Colorado at Boulder, Boulder, CO. http://www.salgsite.org.

Weston, Timothy J., and Sandra L. Laursen. 2015. "The Undergraduate Research Student Self-Assessment (URSSA): Validation for Use in Program Evaluation." *CBE–Life Sciences Education* 14: 1–10. doi: 10.1187/cbe.14-11-0206

Willis, David, Paul Krueger, and Alice Kendrick. 2009. "The Influence of a Research Experiences for Undergraduates Program on Students' Attitudes toward Engineering Research." *Proceedings, American Society for Engineering Education*, 1–10. Austin, TX.

Yoder, Brian. 2013. "Engineering by the Numbers. American Society for Engineering Education." http://www.asee.org/papers-and-publications/publications/14_11-47.pdf

Zydney, Andrew L., Joan S. Bennett, Abdus Shahid, and Karen W. Bauer. 2002a. "Faculty Perspectives Regarding the

Undergraduate Research Experience in Science and Engineering." *Journal of Engineering Education* 91: 291–297. doi: 10.1002/j.2168-9830.2002.tb00706.x

Zydney, Andrew L., Joan S. Bennett, Abdus Shahid, and Karen W. Bauer. 2002b. "Impact of Undergraduate Research Experience in Engineering." *Journal of Engineering Education* 91:151–157. doi: 10.1002/j.2168-9830.2002.tb00687.x

D. Jake Follmer
Pennsylvania State University, djf244@psu.edu

D. Jake Follmer is a doctoral candidate in educational psychology at Pennsylvania State University. He is interested in issues related to learning, assessment, and program evaluation.

Sarah Zappe is research associate and director of assessment and instructional support in the Leonhard Center for the Enhancement of Engineering Education at Pennsylvania State University. She holds a doctoral degree in educational psychology emphasizing applied measurement and testing. In her position, Zappe is responsible for developing instructional support programs for faculty, providing evaluation support for educational proposals and projects, and working with faculty to publish educational research. Her research interests primarily involve creativity, innovation, and entrepreneurship education.

Esther Gomez is an assistant professor in the Departments of Chemical Engineering and Biomedical Engineering at Pennsylvania State University. Gomez's research focuses on the impact of chemical and mechanical signals on cell behavior and function as well as the progression of disease.

Manish Kumar is an assistant professor of chemical engineering at Pennsylvania State University and a co-director of the Penn State REU on integration of biology and materials in chemical engineering. He obtained his PhD in environmental engineering at the University of Illinois at Urbana-Champaign and conducted postdoctoral research at Harvard Medical School. He has seven years of industrial research experience in environmental consulting and is dedicated to training young professionals.

ASSESSMENT

Incorporation and Evaluation of Authentic Research Experiences into the Curriculum through Development of a Theory of Action

Pamela Brown, Tammie Cumming, *New York City College of Technology–CUNY*
Joan D. Pasley, *Horizon Research, Inc.*

Abstract

A theory of action outlining undergraduate research program inputs and desired outcomes was developed and used to guide implementation of Course-Based Undergraduate Research Experience (CURE) sections and to create assessment tools to measure attainment of program goals in both apprentice-model undergraduate research and CURE. Student survey results for these two research programs were compared and suggest that many aspects of the academic goals such as designing an experiment, using equipment, collecting and analyzing data, and collaborating with others were achieved in both groups. Regarding the relationship with mentors, both groups reported receiving academic advisement in course selection and career options. Students in the apprentice-model program were more likely to discuss managing time, establishing career goals, networking, applying to graduate school, and building professionalism with their mentors. Students in the apprentice-model program also reported more time working with their research mentor, a higher quality research experience with their mentor, greater gains in communicating research findings, and more confidence in their research ability and future career path, at a statistically significant level. This approach and information may be useful to faculty mentors in improving the undergraduate researcher experience.

Keywords: *theory of action, apprentice model, course-based, authentic research experience, undergraduate research*

doi: 10.18833/spur/1/1/9

New York City College of Technology, a branch of the City University of New York (CUNY), is a minority serving, open-access public institution. The college participated in a series of "Institutionalizing Undergraduate Research" workshops for mission-similar institutions focused on leadership and Council on Undergraduate Research (CUR) skills development (NSF 0920275, Elizabeth L. Ambos, principal investigator). A resulting goal was to expand authentic research experiences into the classroom to increase the number of students benefiting from undergraduate research. When the CUNY Central Office of Academic Affairs subsequently released a Student Success Request for Proposals (RFP) in fall 2013, the college successfully applied for funding to support "City Tech: Assessing the Impact of Undergraduate Research on Degree Attainment and Student Success." The project involved three major components:

1. Assessment of student outcomes for the college's Emerging Scholars program, an apprentice-model undergraduate research program in existence since fall 2006. Students in this program receive $500 stipends per semester of undergraduate research and are expected to conduct approximately 50 hours per semester of work as well as attend four professional development workshops on topics such as researching in libraries, writing abstracts, preparing posters, and understanding safety and ethics. They also submit an abstract and participate in the college's poster session at the end of each semester.
2. Expansion of Course-Based Undergraduate Research Experiences (CURE) into four laboratory courses and their assessment.
3. Development of a theory of action to guide the design and implementation of the CURE and development of assessment tools.

Previous work has reported on key aspects of CURE (Auchincloss et al. 2014). The Course-Based Undergraduate

Research Experiences Network (CUREnet) drafted an operational definition of a CURE that articulated what makes a laboratory course or project a "research experience." The five components of the definition are (1) use of scientific practices, (2) discovery, (3) broadly relevant or important work, (4) collaboration, and (5) iteration. These components can be described through a quantifiable framework. Instructors may use the framework to delineate their instructional approach, clarify what students will be expected to do, and articulate their learning objectives. Auchincloss and colleagues further reported that most studies reporting assessment of CUREs in the life sciences have made use of the CURE Survey (Lopatto 2010). The CURE survey is composed of three elements: (1) an instructor report on the extent to which the learning experience resembles the practice of science research, (2) student reports of learning gains, and (3) student reports of attitudes toward science.

The authors of this article hypothesized that CURE implementation was likely to be more successful if it took into account the context of the institutional mission and complemented other ongoing initiatives. To provide an institution-specific framework for the integration and evaluation of CURE as well as to better articulate and evaluate the apprentice-model undergraduate research program, a theory of action was developed and used to create assessment tools.

Development of the Theory of Action

A program theory of action is "an explicit theory or model of how an intervention, such as a project, a program, a strategy, an initiative, or a policy, contributes to a chain of intermediate results and finally to intended or observed outcomes" (Funnell and Rogers 2011). Theories of action are used broadly in both strategic planning and program evaluation (Frechtling et al. 2010; Patton 2008). For example, a well-articulated theory of action can be used for project planning purposes such as to develop agreement among various stakeholders about the nature of the program and serve as the basis for identifying whether programs are working.

Various methods can be used to develop or elicit a theory of action. Funnell and Rogers (2011) describe three approaches. The first, *articulating a program stakeholder mental model,* involves working with individuals to articulate how they understand a program to work or how they would like to see the program work—in other words, what the program would look like if it were successful. The second approach, *deductive development* of a theory of action, involves identifying the problem to be addressed as well as the causes, consequences, and effective practices through the review of formal and informal documentation such as relevant research and professional experiences. A theory of action can also be developed through an *inductive approach*, which involves inferring the program theory from the operation of the program based on observation and interviews with key stakeholders.

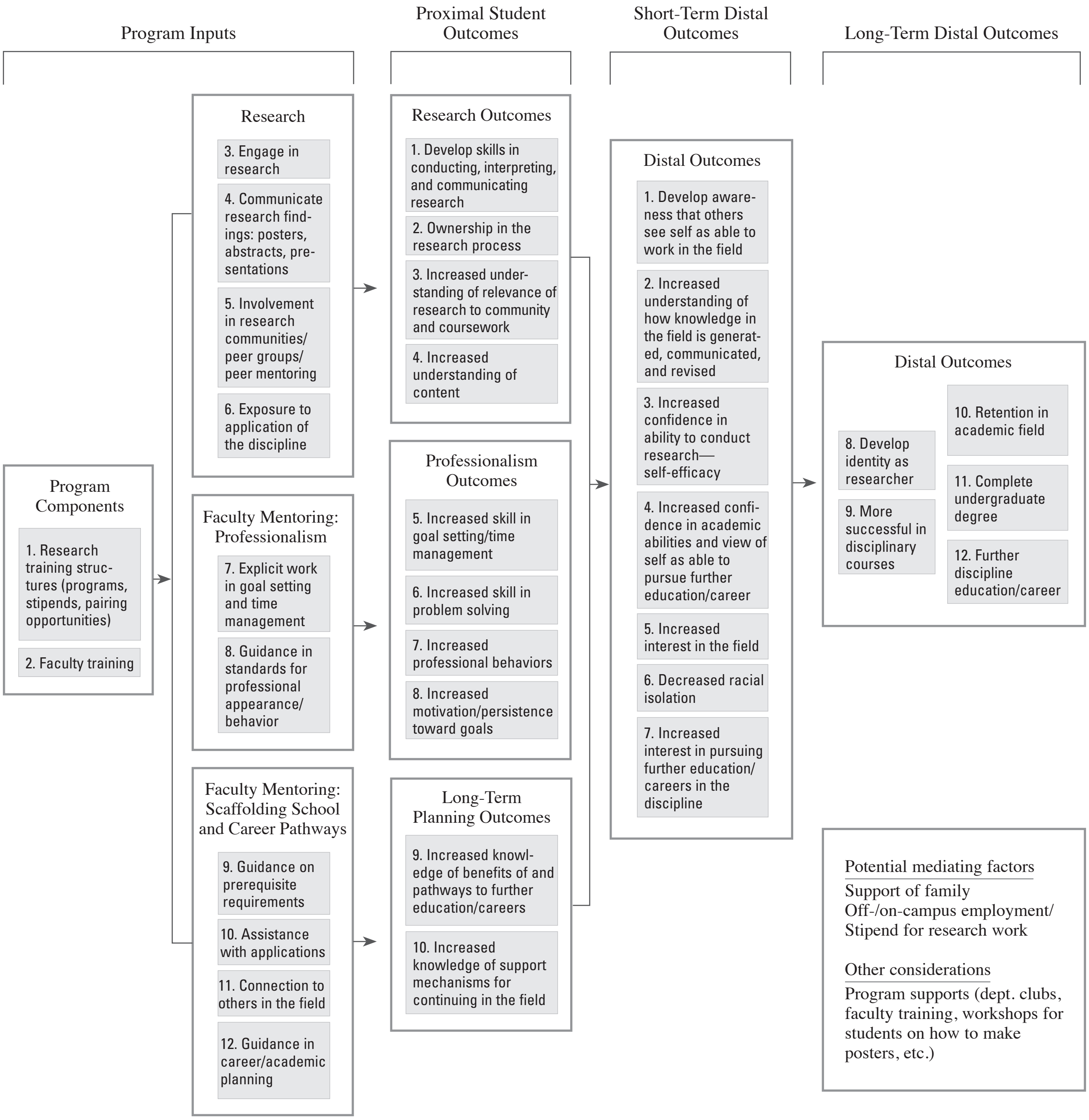
The project research partner Horizon Research, Inc. (HRI), used a combination of these approaches in developing a theory of action for the City Tech Undergraduate Research programs. First, HRI reviewed information on the apprentice-model undergraduate research program found on the City Tech website, along with information from the funding proposal. HRI also reviewed research examining the features of undergraduate research experiences and the impact of those experiences on students (e.g., Chang et al. 2014). This information was used to construct an initial theory of action for the program. The third data source was focus group interviews conducted at City Tech in May 2014 by HRI researchers. One focus group was conducted with members of the Undergraduate Research Committee (URC), who provided information on the characteristics and impacts of successful and less successful research experiences. URC is a group of City Tech faculty supporting undergraduate research through faculty mentoring efforts, faculty and student recruitment, and dissemination of information. Additionally, the URC reviewed the initial draft of the theory of action and provided feedback.

HRI also conducted three focus group interviews with 18 faculty members at City Tech representing 11 departments: architectural technology, biological sciences, chemistry, computer engineering technology, English, hospitality management, mathematics, mechanical engineering technology, nursing, physics, and social science. All but one faculty member had served, or was currently serving, as a faculty mentor in the undergraduate research program. During these focus groups, participants were asked to describe the effects of the most successful research experiences on students and to specify the elements that they believed led to those effects. Faculty members were also asked to describe characteristics of less successful research experiences. Finally, faculty members were asked about any barriers to offering high-quality research experiences for students and any additional resources they needed.

Participant responses were analyzed to identify common themes and revise the theory of action. The final theory of action is shown in Figure 1. The diagram is divided into three sections: (1) program inputs (PI), (2) proximal student outcomes (PO), and (3) short-term and long-term distal outcomes (DO).

The "program inputs" include experiences students may have as part of the City Tech undergraduate research program that includes centrally offered training in research skills, various aspects of the research experience, and mentoring on skills needed to work in a professional environment and preparation for future coursework and careers.

FIGURE 1. City Tech's Theory of Action in Its Undergraduate Research Program



The proximal student outcomes—those expected as a direct result of the research experience—include outcomes specific to learning about and experiencing research (such as skills in conducting, interpreting, and communicating research); outcomes related to professionalism (such as time management); and outcomes related to a students' long-term planning (such as increased knowledge of pathways to education and careers). The short- and long-term distal outcomes are outcomes expected as a result of students developing knowledge, skills, and attitudes from the research experience as well as the mentoring provided to them. For example, after successfully implementing a research project and having ownership in the process, students would develop awareness that others would see them as able to work in the field, would experience increased confidence in their ability to conduct research, and would eventually pursue further education and possibly a career in the discipline.

The theory of action was used to guide the design and implementation of the CURE sections and was also used in the development of tools that would be used to assess the quality and impact of both categories of research experiences. A description of these follows.

Design and Implementation of CURE

An RFP for faculty to implement CURE in a laboratory course was developed and forwarded to all full-time faculty members. The RFP included the CUR definition of undergraduate research, a brief literature survey highlighting some of the benefits of undergraduate research/inquiry-based learning, overarching curricular goals, eligibility, and budgetary and submission guidelines. A rubric was then developed for proposal evaluation that aligned with stated curricular goals (see http://www.citytech.cuny.edu/research/docs/Appendix_1_Proposal_Review_Rubric.pdf). The college's URC evaluated the submitted proposals. Funding was awarded to the most meritorious proposals for faculty summer salary for curricular development, and start-up materials and supplies for at least one section of the course. Prior to the official award, reviewer concerns were presented to the proposal submitters so that they could address and strengthen their projects. The participating faculty members were encouraged to incorporate the various components of the theory of action into the revised sections. Two CURE sections were first offered in fall 2014 and two in spring 2015. Three of the four CURE courses receiving funding were lower level, and one was upper level. One CURE section, General Biology I Laboratory, was not offered in spring 2015 when the survey administration occurred because of faculty teaching assignments and was not included in the survey. A fifth CURE section of General Chemistry II Laboratory, supported with alternate college funds but using the same approach, was included. A summary of all five CURE curricular innovations is presented in Table 1.

TABLE 1. Highlights of CURE Curricular Innovations

Course	Role in the curriculum	Curricular innovation	Enrollment, spring 2015
Advanced Solids Modeling, IND 2304	Required sophomore-level course in the associate in applied science degree programs in both mechanical engineering technology and industrial design and the bachelor of technology degree in mechanical engineering technology.	Students design and fabricate custom-designed orthopedic metallic implants (CDOI). Unlike the old course content that focused solely on software skills, the new approach motivates students to solve challenges in design, materials, and fabrication of metallic implants.	19
Plastic Product Manufacturing, MECH 4720	Required senior-level course in the bachelor of technology degree in mechanical engineering technology.	Groups of students choose a unique product to design. They conduct research into product specifications, customer needs, mechanical properties, and design issues related to environmental concerns. They then make the product and evaluate its performance to develop recommendations for improvement.	19
Network Fundamentals, CST 2307	Required sophomore-level course in the associate in applied science degree in computer information systems and the bachelor of technology degree in computer systems technology.	Students develop research questions related to networking challenges and create unique protocols to solve them. They then test their protocols using simulation labs.	24
General Chemistry II Lab, CHEM 1210L	Required freshman-level course in the associate in science degree in chemical technology, the bachelor of science degree in applied chemistry, and a required course or elective in several other majors. Also satisfies the general education scientific world requirement.	Students obtain samples of Hudson River water, develop research questions, and measure properties such as pH and conductivity to answer those questions.	24
Biology I Lab, BIO 1101L	Required freshman-level course in BS in bioinformatics, applied mathematics, and allied health degrees. Meets the general education life and physical sciences requirement.	Case study on measuring glucose to illustrate the analytical techniques in urinalysis. Forensic case study for studying paternity using DNA fingerprinting. Learning objectives in laboratory exercises were rewritten to be in the form of a question.	Not offered

Development of Assessment Materials

The final theory of action was used to revise the survey that had been administered in the past to students participating in the City Tech undergraduate research program; this was a version of the Undergraduate Research Student Self-Assessment or URSSA (Hunter et al. n.d.), which better aligned with the theory of action than the CURE Survey of Lopatto (2010). The URSSA items were mapped to the theory of action to determine the alignment. The mapping process indicated that, although there were a number of components of the theory of action that were addressed by the existing student survey, many components were not covered at all or were addressed by only one or two items.

As a result of this analysis, the survey was revised to better align with the theory of action and to gather additional data about the nature of students' research experiences, their activities during the experience, and their beliefs about what they gained. It should be noted that it was not feasible to examine every area depicted in the theory of action.Thus, a necessary part of the revision process was to prioritize the components of the theory of action that were most important to measure and for which reasonably reliable survey items were available. A cross-walk showing the theory of action mapped to the revised student survey is provided in Table 2. Although it was not feasible to do so in this context, it may also be possible to split the components among multiple surveys administered at different times so that no single survey is overly burdensome. For example, a survey could be administered that asks students about the nature of their research experience and the more proximal outcomes each year they participate, with the more distal outcome questions posed every other year or just before students graduate.

In addition to the revised student survey, a faculty survey was developed using the theory of action to collect information on their perceptions of the nature of the student experience, resources used, barriers encountered during the experience, and additional support elements that would help the faculty in the future. Survey results from the faculty and student surveys would thus allow the college to examine relationships between student and faculty responses about the program leading to improved experiences and outcomes. Discussion of those results is beyond the scope of this article.

Assessment Methodology

The revised postresearch experience survey was administered to the 132 participants conducting research under the apprentice model in the Emerging Scholars (ES) Program and 86 students in CURE sections during the last two weeks of the spring 2015 semester. Results for the two groups were analyzed and compared. Statistical analyses were conducted via a Chi-square for dichotomous response items, whereas an independent *t*-test with the Welch-Satterthwaite correction for unequal sample sizes and unequal variance was conducted for the Likert-type scale items.

Discussion of Results

The results for statistically significant differences for each of the goals measured in this study are presented in Table 3 (nature of the experience), Table 4 (quality of the experience), and Table 5 (impacts of the experience).

Nature of the Experience

Both groups (ES and CURE) reported that the mandatory workshops (and, for CURE individuals, in-class discussions) on using the library, database search methods, safety, and ethics training supported their learning. There was no statistically significant differences in the reported ratings of learning opportunities for designing an experiment, learning to use scientific equipment, collecting and analyzing data, connecting the field of research to industry and real-world settings, and collaborating with other students The results also suggest that students felt that both CURE and the ES program contributed to developing important academic skills. However, as shown in Table 3, at a statistically significant level, students in the ES apprentice model were more likely to conduct library research, develop a research question, and present a talk or poster than the CURE students. This suggests that greater focus on building communication skills, developing a research question, and conducting library research in CURE sections would better emulate the ES apprentice model.

Both groups also reported discussing academic/career goals, course selection, time management, graduate school and the graduate school application process, networking strategies, and professional behaviors with their mentor. Discussion of academic/career goals, time management, applying to graduate school, and professional behaviors was more likely to happen at a statistically significant level in the ES apprentice model. Thus another possible area of focus in CURE is intentional reflection and information on personal goal-setting, time management, and professionalism.

Students in the ES program reported working on their project an average of 9.4 hours per week, significantly more than the 5.4 hours per week in CURE sections. Given a 15-week semester, this suggests that students are devoting much more than the 50 hours expected for program participation. Students in the apprenticeship-model research program may have more access to laboratories or may simply be more committed to their project.

Quality of the Experience

Both groups reported receiving training on safety and ethics. As shown in Table 4, although both groups gave

TABLE 2. Survey Alignment with City Tech's Undergraduate Research Program Theory of Action

Theory-of-Action component	Corresponding survey items
Program components	
PI-1 Research training structures (programs, stipends, pairing opportunities)	8
PI-2 Faculty training	
Research experience	
PI-3 Engage in research	1, 3, 4 ,6, 7
PI-4 Communicating research findings: posters, abstracts, presentations	1
PI-5 Involvement in research communities/peer groups/peer mentoring	1, 3, 7
PI-6 Exposure to application of the discipline	1
Faculty mentoring: Professionalism	5, 6, 7, 9, 11
PI-7 Explicit work in goal setting and time management	2
PI-8 Guidance in standards for professional appearance/behavior	2
Faculty mentoring: Scaffolding school and career pathways	5, 6, 7, 9, 11
PI-9 Guidance on prerequisite requirements	2
PI-10 Assistance with applications	2
PI-11 Connecting with others in the field	2
PI-12 Guidance in career/academic planning	2
Research outcomes	
PO-1 Develop skills in conducting, interpreting, and communicating research	12, 13
PO-2 Ownership in the research process	14
PO-3 Increased understanding of relevance of research to community and coursework	12, 13
PO-4 Increased understanding of content	12
Professionalism outcomes	
PO-5 Increased skill in goal setting/time management	10, 14
PO-6 Increased skill in problem solving	12
PO-7 Increased professional behaviors	10, 14
PO-8 Increased motivation/persistence toward goals	10, 15
Long-term planning outcomes	
PO-9 Increased knowledge of benefits of and pathways to further education/careers	15
PO-10 Increased knowledge of support mechanisms for continuing in the field	15
Short-term distal outcomes	
DO-1 Develop awareness that others see them as able to work in the field	14
DO-2 Increased understanding of how knowledge in the field is generated, communicated, and revised	12, 13
DO-3 Increased confidence in their ability to conduct research—self-efficacy	12
DO-4 Increased confidence in academic abilities and viewing themselves as able to pursue further education/career	12, 15
DO-5 Increased interest in the field	15
DO-6 Decreased racial isolation	
DO-7 Increased interest in pursuing further education/careers in the discipline	15

Note: PI = program inputs, PO = proximal student outcomes, DO = distal outcomes

high ratings to their working relationship with the mentor, group members, time spent doing meaningful research, and advice received from the mentor, there was a statistically significant increase in the ratings reported by those in the ES program compared to CURE respondents. The increase was reported in support and encouragement, constructive and useful critique of work, motivating, answering questions, acknowledging contributions and extending abilities by being challenged by the mentor, among others. This suggests that, although scale-up from the apprentice model to CURE is possible, some benefits may be lost. This may be due to time on task. Although in theory the time spent time in each program over a semester is comparable (approximately 50 hours per semester in the ES programs compared to a one-credit laboratory course of approximately 45 hours per semester), students reported spending approximately 4 more hours per week working on their project in the ES program. Another explanation is the opportunity for more individualized attention from the mentor. A possible direction for a relatively low cost

TABLE 3. Highlights of Statistically Significant Postundergraduate Research Experience Survey Responses—Apprenticeship-Model Emerging Scholars (ES) Compared to CURE Spring 2015—Nature of Experience (Most Recent Experience)

1. Which of the following did you do as part of your most recent research experience?
(Select all that apply)—method: X^2 Independence[c]

Q1	ES results[a]	Cumulative CURE results[b]
Library research	48%	23%
Developed a research question	38%	10%
Presented a talk	34%	15%
Presented a poster	73%	10%

2. Which of the following did you discuss with your mentor?
(Select all that apply)—X^2 Independence[c]

Q2	ES results[a]	Cumulative CURE results[b]
Your academic/career goals	59%	39%
Time management	60%	34%
The process for applying to graduate school	21%	3%
Networking with other professionals	38%	15%
Professional behaviors and/or appearance	34%	15%

3. How often did you do each of the following?
1 = Never, 2 = Rarely (e.g., once or twice during the semester), 3 = Sometimes (e.g., once or twice a month), 4 = Often (e.g., once or twice a week)—*t*-test[c]

Q3	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Worked with your research mentor on your research project	3.8	0.9	2.9	1.1	t = -6.00
Read papers related to your research project written by your mentor	3.0	1.2	2.5	1.0	t = -2.78
Read papers related to your research project *not* written by your mentor	3.3	1.1	2.8	1.0	t = -2.89

4. How many hours per week did you work at research-related activities?
3 = 1–5 hours, 8 = 6–10 hours, 13 = 11–15 hours, 18 = 16–20 hours, 21 = 21 or more hours—*t*-test[c]

Q4	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
How many hours per week did you work at research-related activities?	9.4	6.0	5.4	3.5	t = -5.02

5. On average, how many hours per week did you spend talking with your mentor?
1 = 1 hour, 2 = 2 hours, 3 = 3 hours, 4 = 4 hours, 5 = 5 or more hours—*t*-test[c]

Q5	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
On average, how many hours per week did you spend talking with your mentor during your most recent research experience?	2.9	1.5	1.8	1.0	t = -5.85

[a]ES results N = 82/132, 62% response rate
[b]Cumulative CURE results, N = 61/86, 71% response rate
[c]Significance level, $p < .05$

may be adding peer mentors in CURE sections to help support group dynamics and provide more personalized mentoring.

Impacts of the Experience

There was no statistically significant differences in reported gains related to analyzing data for patterns, problem solving in general, understanding the theory and concepts guiding the research project, engaging in scientific writing, defending an argument, maintaining a lab notebook, making observations, using statistics to analyze data, calibrating instruments, working with computers, strengthening interest in the field of study, preparing for graduate school or employment, heightening motivation, or advancing in knowledge. As shown in Table 5, at a statistically significant level, students in the ES program reported greater gains in making oral presentations, preparing posters, understanding journal articles, and conducting database or Internet searches. Additionally, at a statistically significant level, students in the ES program reported greater confidence for future research or advanced coursework and greater gains in their mentor's confidence in them. These results correlate with findings already discussed in the nature of the experience—more effort to incorporate professional communication skills in CURE sections is an area for improvement, as this could both improve communication skills and confidence.

TABLE 4. Highlights of Statistically Significant (*t*-test[a]) Postundergraduate Research Experience Survey Responses—Apprenticeship-Model Emerging Scholars (ES) Compared to Course-Based Undergraduate Research Experiences—Spring 2015—Quality of Experience

1. Please rate the following regarding your research experience:
Missing = N/A, 1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent

Q6	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
My working relationship with my research mentor	3.7	0.7	3.0	1.4	$t = -5.06$
My working relationship with research group members	3.5	1.4	3.0	1.4	$t = -3.49$
The amount of time I spent doing meaningful research	3.4	0.9	3.1	1.4	$t = -2.75$
The amount of time I spent with my research mentor	3.5	0.9	2.7	1.3	$t = -5.06$
The advice my research mentor provided about careers or graduate school	3.4	1.4	2.8	1.4	$t = -3.25$
The research experience overall	3.7	0.8	3.1	1.3	$t = -4.50$

2. Please rate the following aspects of your most recent research experience:
Missing = N/A, 1 = Very dissatisfied, 2 = Somewhat dissatisfied, 3 = Somewhat satisfied, 4 = Very satisfied

Q7	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Support and guidance from program staff	3.6	1.3	3.2	1.4	$t = -2.85$
Support and guidance from my research mentor	3.7	0.9	3.3	1.1	$t = -3.28$
Support and guidance from other research group members	3.6	1.5	3.2	1.4	$t = -2.67$
Research group meetings	3.5	1.4	3.1	1.4	$t = -2.83$

3. How much did the following activities support your learning?
Missing = N/A, 1 = Not at all, 2 = A little, 3 = A good amount, 4 = A great deal

Q8	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Session(s) on science writing and presentation	3.3	1.3	2.9	1.3	$t = -2.30$

4. Indicate the extent to which you agree or disagree with each statement listed below:
1 = Strongly disagree, 2 = Disagree, 3 = Slightly disagree, 4 = Agree, 5 = Strongly agree

Q9	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
My mentor was accessible	4.6	0.9	4.2	0.8	$t = -2.93$
My mentor demonstrated professional integrity	4.7	0.9	4.3	0.7	$t = -3.46$
My mentor demonstrated content expertise in my area of need	4.7	1.0	4.4	0.7	$t = -2.62$
My mentor was approachable	4.7	0.9	4.3	0.7	$t = -3.68$
My mentor was supportive and encouraging	4.7	0.9	4.3	0.7	$t = -3.79$

(*table continues*)

TABLE 4. (cont.)

Q9	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
My mentor provided constructive and useful critiques of my work	4.6	0.9	4.3	1.0	$t = -2.90$
My mentor motivated me to improve my work product	4.7	0.9	4.3	0.9	$t = -3.00$
My mentor was helpful in providing direction and guidance on professional issues (e.g., networking)	4.6	1.0	4.2	0.9	$t = -2.91$
My mentor answered my questions satisfactorily (e.g., timely response, clear, comprehensive)	4.6	0.9	4.3	0.9	$t = -2.57$
My mentor acknowledged my contributions appropriately (e.g., committee contributions, awards)	4.6	1.1	4.0	1.0	$t = -3.48$
My mentor suggested appropriate resources (e.g., experts, electronic contacts, source materials)	4.7	0.9	4.2	0.9	$t = -4.13$
My mentor challenged me to extend my abilities (e.g., risk taking, try a new professional activity, draft a section of an article)	4.6	1.2	4.1	1.0	$t = -2.96$

[a]Significance level, $p < .05$

TABLE 5. Highlights of Statistically Significant (*t*-test[a]) PostUndergraduate Research Experience Survey Responses—Apprenticeship-Model Emerging Scholars (ES) Compared to CURE Spring 2015—Impacts of Experience (Most Recent Experience)

1. How much did you gain in the following areas?
1 = No gains, 2 = A little gain, 3 = Moderate gain, 4 = Good gain, 5 = Great gain

Q10	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Managing my time	4.1	1.1	3.6	1.2	$t = -2.61$
Ability to work independently	4.3	1.2	3.9	1.3	$t = -2.07$
Ability to conduct myself in a professional manner (e.g., how to dress, communicate)	4.2	1.2	3.6	1.4	$t = -3.29$

2. How much did you gain in the following areas?
1 = No gains, 2 = A little gain, 3 = Moderate gain, 4 = Good gain, 5 = Great gain

Q11	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Figuring out the next step in a research project	4.1	1.0	3.7	1.2	$t = -2.52$

3. How much did you gain in the following areas?
1 = No gains, 2 = A little gain, 3 = Moderate gain, 4 = Good gain, 5 = Great gain

Q12	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Making oral presentations	3.7	1.4	3.2	1.5	$t = -2.51$
Explaining my project to people outside my field	4.1	1.1	3.6	1.4	$t = -2.98$
Preparing a scientific poster	3.8	1.3	3.3	1.5	$t = -2.40$
Understanding journal articles	3.8	1.4	3.3	1.3	$t = -2.18$
Conducting database or Internet searches	4.2	1.2	3.8	1.1	$t = -2.27$

(*table continues*)

TABLE 5. (cont.)

4. Rate how much you agree with the following statements.
1 = Strongly disagree, 2 = Disagree, 3 = Slightly disagree, 4 = Slightly agree, 5 = Agree, 6 = Strongly agree

Q13	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
My research experience has prepared me for advanced coursework or thesis work	5.2	1.4	4.7	1.2	$t = -2.22$
My research experience has made me aware of different options for furthering my education.	5.1	1.3	4.8	1.2	$t = -2.07$

5. Rate how much you agree with the following statements.
1 = Strongly disagree, 2 = Disagree, 3 = Slightly disagree, 4 = Slightly agree, 5 = Agree, 6 = Strongly agree

Q14	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
My research experience has made me more confident in my ability to conduct research.	5.2	1.5	4.5	1.4	$t = -3.60$
During my research experience, my mentor became more confident in my ability to conduct research.	5.2	1.5	4.5	1.4	$t = -3.47$
My research experience has made me more confident in my ability to succeed in future coursework/career.	5.3	1.6	4.7	1.3	$t = -3.10$

6. Compared to your intentions before doing research, how likely now are you to:
0 = N/A, 1 = Not more likely, 2 = A little more likely, 3 = Somewhat more likely, 4 = Much more likely, 5 = Extremely more likely

Q15	ES		Cumulative CURE		*t* statistic
	Average	Standard deviation	Average	Standard deviation	
Enroll in a PhD program in science, mathematics, or engineering?	3.6	1.8	2.8	1.8	$t = -3.03$
Enroll in a master's program in science, mathematics, or engineering?	3.8	1.9	3.3	1.8	$t = -2.21$
Enroll in a combined MD/PhD program?	3.5	1.8	2.8	1.7	$t = -2.74$

[a]Significance level, $p < .05$

Lessons Learned

Compelling reasons for incorporating authentic research experiences into the curriculum include opportunities to increase the number of students that can benefit beyond the apprentice model—particularly students who might not self-select to participate—and to motivate promising students to continue research. However, this is a relatively new curricular goal with few models of best practices. A theory of action, which articulated program inputs and desired outcomes, was developed after interviewing faculty committed to undergraduate research. The theory of action provided an institutional framework for developing, implementing, assessing, and ideally improving CURE. Analysis of survey results suggested that many aspects of the program goals related to the research experience such as designing an experiment, using equipment, collecting and analyzing data, and collaborating with others were achieved in both groups. In terms of the relationship with their mentors and the quality of the experience, both groups reported receiving academic advisement regarding course selection and career options. Students in the ES apprentice model were more likely to report discussing time management, career goals, networking strategies, graduate school application procedures, and professionalism with their mentors, as well as having an opportunity to communicate research findings, at a statistically significant level. These results suggest areas for improvement in CURE sections such as the following:

1. Incorporate more opportunities for students to conduct library research and communicate their research findings such as a CURE poster session or mini-conference.

2. Schedule faculty-student meetings with individual or small groups of students and faculty to discuss research, additional research opportunities on and off campus, career goals, professionalism, and graduate school. These meetings, of course, would require a very strong commitment on the part of the faculty. Alternatively, institutions could invest in training and hiring peer mentors to fill some of these roles.

Acknowledgments

The authors wish to acknowledge funding by the CUNY Office of Academic Affairs (no grant number), which made this project possible. They also acknowledge the contributions of the CUNY Office of Grants and Research, the Council on Undergraduate Research, and the NSF (0920275, Elizabeth L. Ambos, principal investigator). The authors also wish to acknowledge the faculty teaching the CURE sections who assisted with survey administration: L. Jay Deiner (CHEM 1210L), Gaffar Gailani (IND 2304), Ossama Elhadary (CST 2307), and Mohammad Maneshi-pour (MECH 4720). They also are grateful to the faculty members of the Undergraduate Research Committee who participated in the focus groups and made helpful suggestions to improve the theory of action.

References

Auchincloss, Lisa Corwin, Sandra L. Laursen, Janet L. Branchaw, Kevin Eagan, Mark Graham, David I. Hanauer, Gwendolyn Lawrie, et al. 2014. "Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report." *CBE–Life Sciences Education* 13: 29–40. doi: 10.1187/cbe.14-01-0004

Chang, Mitchell J., Jessica Sharkness, Sylvia Hurtado, and Christopher B. Newman. 2014. "What Matters in College for Retaining Aspiring Scientists and Engineers from Underrepresented Racial Groups." *Journal of Research on Science Teaching* 15: 555–580. doi: 10.1002/tea.21146

Frechtling, Joy, Melvin N. Mark, Debra J. Rog, Veronica Thomas, Henry Frierson, Stafford Hood, and Gerunda Hughes. 2010. *The 2010 User-Friendly Handbook for Project Evaluation*. Arlington, VA: National Science Foundation.

Funnell, Sue C., and Patricia J. Rogers. 2011. *Purposeful Program Theory: Effective Use of Theories of Change and Logic Models*. San Francisco: Wiley.

Hunter, Anne-Barrie, Tim Weston, Heather Thiry, and Sandra Laursen. *URSSA Survey*. Boulder: University of Colorado at Boulder. Accessed January 1, 2016. http://spot.colorado.edu/~laursen/accessURSSA.html

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

Patton, Michael Quinn. 2008. *Utilization-Focused Evaluation*. 4th ed. Thousand Oaks, CA: SAGE Publications.

Pamela Brown
New York City College of Technology–CUNY, pbrown@citytech.cuny.edu

Pamela Brown is associate provost at New York City College of Technology (City Tech) of the City University of New York, where she previously served six years as the dean of the School of Arts & Sciences and as a faculty member in the Chemistry Department. The Emerging Scholars Program, an undergraduate research program at City Tech that has served nearly 1000 students since its inception in 2006, was founded under her leadership. She also previously served as a program director in the Division of Undergraduate Education at the National Science Foundation in 2011–2012. *Her work has focused on creating initiatives to improve the retention and recruitment of students interested in careers in science, technology, engineering, and mathematics. She was the principal investigator of the NSF grant "Metropolitan Mentors: (MMNet): Growing an Urban STEM Talent Pool across New York City" and has served as the co-principal investigator on four other NSF grants and one NIH grant. She holds a PhD in chemical engineering from Polytechnic University (now NYU Polytechnic School of Engineering), an SM in chemical engineering practice from the Massachusetts Institute of Technology, and a BS in chemistry from the University at Albany–State University of New York.*

Tammie Cumming directs the Office of Assessment and Institutional Research at City Tech and serves as a professional development assessment expert for ABET (formerly Accreditation Board for Engineering and Technology). In the latter role, Cumming trains faculty on the assessment process and best practices in quality assurance for technical education worldwide. Cumming also has served as a U.S. delegate for the Organization for Economic Cooperation and Development's assessment initiative and as a research associate and program manager at ACT, Inc.

Joan D. Pasley has been working at Horizon Research, Inc., since 1994 on a number of technical assistance, research, and evaluation projects such as the program evaluation of the Merck Institute for Science Education's Consortium for Achievement in Mathematics and Science. Pasley directs evaluations of several NSF-funded research projects and serves as the co-principal investigator for two NSF-funded projects. The first project, Operationalizing the Science and Engineering Practices, is identifying key aspects of the science and engineering practices articulated in the Next Generation Science Standards, and developing and validating instruments to be used as an indicator of science classroom coverage of the practices. The second project, Stopping an Epidemic of Misinformation: Leveraging the K–12 Science Education System to Respond to Ebola, is studying the response of science teachers to the recent Ebola outbreak.

International
PERSPECTIVES

Undergraduate Research and Student-Staff Partnerships: Supporting the Development of Student Scholars at a Canadian Teaching and Learning Institute

Elizabeth Marquis, *McMaster University*

Abstract

Undergraduate research and inquiry and student-staff partnerships in teaching and learning have much in common, although their connections are not often discussed explicitly. Partnership initiatives—particularly those that engage students in collaborating with faculty/staff on disciplinary research or the scholarship of teaching and learning—share many features with undergraduate research efforts, including the potential to help students develop as active and engaged producers and scholars. Building on these connections, this article describes a unique 'student partners program' housed within the teaching and learning institute at McMaster University (Canada) considering its role in the development of outcomes desired by scholars and practitioners of undergraduate research and student-staff partnership. This assessment can assist in further consideration of the place of partnership within undergraduate research.

Keywords: *co-inquiry, student-staff partnership, students as scholars, students as producers, undergraduate research*

doi: 10.18833/spur/1/1/2

The body of literature focusing on student-faculty partnerships in teaching, learning, and research has grown significantly in recent years (e.g., Cook-Sather, Bovill, and Felten 2014). Partnership approaches, which typically seek to engage students and faculty or staff as active collaborators on pedagogically relevant activities, have been deployed in a range of contexts, including curriculum design, pedagogic consultancy, disciplinary research, and the scholarship of teaching and learning (SoTL; Healey, Flint, and Harrington 2014). Regardless of the context, a key tenet of partnership initiatives is the need to challenge traditional power structures and expand the space for students to work alongside faculty as scholarly co-producers of teaching, learning, and knowledge. As stated by Cook-Sather, Bovill, and Felten (2014, 6–7), partnership is "a collaborative, reciprocal process, through which all participants have the opportunity to contribute equally, although not necessarily in the same ways" to teaching and learning projects.

In many respects, this work on student-faculty partnership resonates with the burgeoning body of scholarship exploring undergraduate research and inquiry. Of course, not all partnership initiatives involve research (or undergraduates), and not all undergraduate research entails partnership with faculty or staff. Where partnership initiatives focus on engaging undergraduate students as co-inquirers in discipline-based research or SoTL, however, the potential overlap is clear. For example, discussions of students as co-inquirers within the partnership literature (e.g., Werder and Otis 2010) have much in common with work addressing students as researchers (Levy 2011) or as producers (Neary 2014), insofar as all of these framings hinge on an understanding of students as active, scholarly contributors to research and education. Similarly, some work on undergraduate research (e.g., Shanahan et al. 2015) takes up issues relevant to partnership without necessarily discussing partnership by name or endorsing that framing. Indeed, comparatively little scholarship has considered explicitly the connections between these bodies of work.

There are certainly exceptions to this trend. Little (2011), for instance, includes several chapters on undergraduate research within an edited volume on student-staff partnership. Healey, Flint, and Harrington (2014) make these connections even more explicit, positioning "students as partners in subject-based research and inquiry" as one of four main categories of partnership and pointing to a range of examples of undergraduate research that connect with a partnership approach. Amongst other things, they consider where partnership might occur within established models of engaging students in research and inquiry, suggesting that it is more likely to be found, for example, in the "research-tutored" and "research-based" quadrants of Healey's well-known model (Healey and Jenkins 2009), or in the "student framed" modes of inquiry-based learning set out by Levy (2011). Such examples begin to make clear important points of contact between two congruent bodies of literature that have much to offer each other.

Taking this frequently overlooked congruence as its starting point, this article describes and assesses a novel "student partners program" at McMaster University in Canada, positioning this initiative as a means of fostering and supporting outcomes aligned with those desired by practitioners of undergraduate research and inquiry. Beyond noting the potential of such an initiative to promote traditional research skills, this article argues that development of the capacity to work in partnership is itself a significant scholarly outcome that considerations of undergraduate research might explore more actively. On one hand, the ability to collaborate meaningfully with a range of research partners is itself a useful skill, particularly given the increasing prominence of collaborative research and the commonality of group work across a range of life situations. At the same time, by emphasizing deep and active engagement in education as a process (rather than consumption of it as a reified product), student-faculty partnerships can contribute to destabilizing the dominant, neoliberal metaphor of students as consumers in higher education (McCulloch 2009). In this way, partnership can support the development of the active and engaged "student as producer" (Neary 2014) or "student as scholar" (Hodge et al. 2011; Curley and Schloenhardt 2014) identities often championed by advocates of research-based education. Indeed, as noted by Brew (2006, 32), the notion of student-staff partnership is central to the "inclusive scholarly knowledge-building communities" fundamental to bridging the teaching-research divide.

The McMaster Context

McMaster University is a mid-size, medical-doctoral institution in Hamilton, Ontario. It currently enrolls approximately 22,000 undergraduates and 3,500 graduate students in programs that sit within and/or draw from six major faculties (business, engineering, health sciences, humanities, science, and social sciences). As a research-intensive institution that simultaneously seeks to prioritize the student experience, the university has a relatively long history of fostering and supporting research-based learning, including a well-established award program for undergraduate student research (Vajoczki 2010), and the deployment of inquiry approaches in several—although by no means all—courses and programs (Cuneo et al. 2012; Justice et al. 2009). In a recent strategic visioning process, the university reaffirmed its commitment to such approaches, defining itself as a "research focused student centred" institution and thereby positioning the fusion of research and teaching as central to McMaster's institutional identity (Forward with Integrity Advisory Group 2012).

The MacPherson Institute—the university's central teaching and learning unit—aims to contribute to the realization of this vision in several ways. Continuing the former teaching and learning center's support for inquiry-based learning (Cuneo et al. 2012), a campus-wide research working group on undergraduate research and inquiry was recently established, and this topic was positioned as a priority area for research conducted and supported by the institute. Mick Healey was also appointed as a distinguished scholar affiliated with the unit in 2015, with the mandate of supporting initiatives connected to research-based learning and student partnerships and mentoring junior scholars in these areas. Finally, a novel student partners program was designed to provide students with opportunities to partner with faculty and staff on teaching and learning research (and other pedagogical initiatives) outside the formal curriculum. This article focuses on the latter initiative.

The Student Partners Program

The Student Partners Program (SPP) was developed collaboratively by the MacPherson Institute and the undergraduate Arts & Science program—a program that itself has a long history of interdisciplinary, inquiry-based learning (Jenkins, Ferrier, and Ross 2004). At its core, the SPP aims to foster the development of meaningful student-faculty/staff partnerships that contribute to the enhancement of teaching and learning at McMaster while providing opportunities for personal and professional development for all individuals involved. Three times a year, MacPherson staff (often working collaboratively with faculty, staff, and/or students from other departments on campus) are invited to submit projects to be considered for inclusion in the SPP. The projects must focus on teaching and learning in some way and typically involve co-design of courses or curricula, or (most commonly) co-inquiry on scholarship of teaching and learning projects. Research projects included in the program to date have drawn from a wide range of disciplinary paradigms and methodological approaches. In 2015–2016, for example, program research ranged from a mixed-methods study of the impact of collaborative testing on student performance in undergraduate physics courses and a qualitative investigation of instructors' experiences of pedagogical innovation to a project involving critical close reading of the representations of higher education in popular film.

A committee consisting of students and staff reviews all project proposals to ensure they align with program goals and provide meaningful opportunities for collaboration and student contributions to the intellectual direction of the work. Accepted projects are then circulated in a call for applications, and students are invited to select work of interest to them and write an application statement that explains their attraction to the project and goals for its development. In this way, they are encouraged to articulate directions and raise ideas that might shape future stages of the project at the outset of the application process.

Ultimately, selected students are hired to work at MacPherson (in paid positions) for up to 10 hours a week during one or more academic terms, becoming full members of institute project teams. Throughout this time, they work collaboratively with their faculty/staff partners to determine the specific nature of their contributions and the ways in which the team will work together. Regardless of the type of project involved, the aim is to develop working relationships that align with the definition of partnership by Cook-Sather and colleagues (2014); students and staff should have opportunities to contribute substantively and to develop a sense of shared ownership for the work. Students working on SoTL research, for example, often become heavily involved in project design, data collection and analysis, and/or dissemination of findings, with several coauthoring conference presentations or publications connected to their work. Partners are encouraged to meet frequently (particularly early in the project) to get to know one another and establish trust; and to have frank conversations up front about expectations, timelines, and individual and collective goals.

In winter 2014, the program was piloted with 13 undergraduate students representing years 1 to 4 of the Arts & Science program. Subsequently, responding to calls to make partnership opportunities as broadly available as possible (e.g., Felten et al. 2013), the program was expanded to include undergraduate and graduate students from across campus. Currently, approximately 50 students work as student partners during each academic term. Since the program's inception, more than 115 students have participated, many for multiple work terms. The vast majority of these students (more than 80 percent) are undergraduates who are mainly in their second, third, or fourth years of study. Thus far, most (more than 70 percent) have been women. Students from all faculties on campus have taken part, with the largest concentrations coming from the Faculty of Science and the Arts & Science program.

Assessment of the Program

Like work focusing on undergraduate research and inquiry, existing scholarship suggests the benefits of partnership approaches are manifold. Most germane to the present exploration, some research illustrates that students involved in partnership work develop an increasing sense of responsibility for their education and come to view themselves as active collaborators and co-producers within an academic environment (e.g., Cook-Sather and Luz 2015). This work resonates with scholarship on the potential of "students as producers" initiatives to counter discourses of academic capitalism (Neary 2014) and with literature on the ability of inquiry-based learning to increase students' self-direction and sense of responsibility for their learning (Hodge et al. 2011).

At the same time, some authors have noted that the benefits of student-faculty partnership have often been assumed and promoted uncritically, whereas—in fact—positive partnership outcomes are neither assured nor always easy to promote (Allin 2014). Navigating existing hierarchies and institutional structures to develop meaningful partnerships is often especially challenging, and both students and faculty may express resistance or experience uncertainty about how to proceed (Bovill et al. 2016). The time required to build effective partnerships exacerbates these challenges, particularly since students are often involved in projects for comparatively short periods (Levy, Little, and Whelan 2011). Finally, Felten and colleagues (2013) and Bovill and colleagues (2016) note the need to consider carefully the relative inclusivity of student-faculty partnerships, pointing out that partnership opportunities are sometimes restricted to a small group of relatively privileged students and that the benefits of such approaches are thus diminished or restricted.

Such considerations provide the basis for the ongoing assessment of the student partners program and the extent to which it is able to meet its goals of developing meaningful partnerships and providing opportunities for personal and professional growth. On a surface level, the involvement of students in more than 70 projects through the Student Partners Program has provided those students with valuable opportunities to engage in research (and other teaching and learning initiatives) that draw from a range of epistemological and methodological approaches. Likewise, at least 45 of these students have coauthored publications and conference presentations with faculty and staff partners to date, with further submissions in development on a continuous basis. These are promising signs. Nevertheless, they reveal a limited amount about the effectiveness and benefits of the partnerships for the participants.

With this in mind, a group of students and staff collaborated during the program's pilot year to develop an exploratory research project investigating participant experiences (Marquis et al. 2016). Acknowledging the simultaneously troublesome and potentially transformative character of partnership work, this research followed Cook-Sather (2014) in positioning student-faculty/staff partnership as a threshold concept for teaching and learning—a centrally important concept that is difficult to master but ultimately leads to substantial and durable shifts in understanding (Meyer and Land 2006). Although this threshold might look slightly different for students and faculty/staff, it was argued that two essential features for both groups would be involved:

- understanding teaching and learning as a collaborative endeavor for which faculty, staff, and students have shared responsibility and
- acting effectively on that understanding so as to realize partnership in practice.

The research team (four students and four staff) took an auto-ethnographic approach to assess the extent to which they crossed this threshold successfully during the first year of the Student Partners Program. A series of reflective prompts were co-developed on topics ranging from understandings of partnership to challenges and successes experienced working on the projects, and participants completed individual reflective responses to these sporadically over a two-month period. Subsequently a focus group involving seven of the eight team members was convened, during which the co-developed prompts were used to guide discussion. The qualitative data were then analyzed thematically, using constant comparison.

Significantly, many (but not all) participating students offered comments that were indicative of developing a new sense of themselves as active, collegial contributors to teaching and learning, although some suggested that this was not always a smooth or comfortable transition. Likewise, the data provided several examples of participants successfully realizing partnership goals in their work, as both students and faculty described moments of experiencing a sense of shared responsibility for their projects and offered examples of how the diversity of perspectives involved ultimately enhanced the work being undertaken. Nevertheless, participants also noted a range of challenges they experienced in working toward those goals, citing discomforts and difficulties navigating traditional roles and expectations as well as time pressures that often tested the development of working relationships and prevented the partnerships from reaching full strength. (See Table 1 for a summary of the findings, and Marquis et al. 2016 for further details).

This range of findings suggested that the Student Partners Program can build participants' capacity to work in partnership but that strategies were needed to address the difficulties encountered by students and faculty/staff. A group of staff and students subsequently developed a guidebook for participants in the program, which presented a range of recommendations based on the authors' experiences and readings of the literature—including the previously mentioned points about frequent meetings and candid discussions of expectations. Follow-up case

TABLE 1. Summary of Key Themes Resulting from Pilot Research

Issues connected to enacting partnership	Shifts in understanding for those involved
Challenges navigating traditional roles	New perspectives on one's role
Difficulty balancing guidance and self-direction	New perspectives on teaching and learning
Time pressures and constraints	
Students playing meaningful roles	
Enhanced work	

Source: Marquis et al. 2016

studies developed by students and staff participating in subsequent iterations of the program (Marquis et al. forthcoming) suggest these increasing refinements (along with the growing experience of staff and students) have proven beneficial, although further research exploring these developments is merited.

One additional issue that bears consideration is the question of inclusion and diversity raised by Felten and colleagues (2013) and Bovill and colleagues (2016). As a paid opportunity outside the curriculum, the Student Partners Program will always have the problem of needing to select participants and thus can never be fully inclusive. In this way, it shares features of extracurricular undergraduate research opportunities that are only available to a select group (Healey and Jenkins 2009). Nevertheless, the comparatively large number of students accepted by the program each year mitigates this issue to some degree, providing an expanding body of students with a more thorough partnership experience than they might otherwise encounter within a course or program. Furthermore, drawing from recommendations made by Bovill and colleagues (2016), the call for student participants is being refined with an eye toward including participants with a wide range of experiences and perspectives, such as members of equity-seeking groups and those traditionally marginalized in higher education. Although such efforts are only a first step in a larger process, they should assist in enhancing the inclusivity of the program.

Implications and Conclusions

Considerations of research-based learning often emphasize how such pedagogical approaches can help students develop as active scholars and knowledge producers, rather than positioning them as passive recipients of information. Strategies and initiatives that emphasize the development of student-faculty partnerships, exemplified here by McMaster's Student Partners Program, can likewise contribute to such desirable outcomes—perhaps even more so by virtue of their explicit emphasis on partnership and collaboration. Although the McMaster program is certainly not the only model for developing partnership, the experiences at this institution highlight a number of factors that might be of interest to others considering such work, including the benefits and challenges of a paid, extracurricular program supported by a central unit, the value of engaging in reflection and research as the program develops, and the significance of collaboratively developing and documenting refinements in materials like the coauthored guidebook previously mentioned (available at https://mi.mcmaster.ca/student-partners-program/). Perhaps most important, ongoing evaluation suggests an approach like the Student Partners Program can develop student and staff capacity to work in meaningful, collaborative relationships that encourage a sense of shared responsibility, ownership, and intellectual contribution. Likewise, the challenges experienced by partners in moving toward these outcomes illuminate the potential difficulties in meaningfully destabilizing the "student as consumer" model.

With these factors in mind, more explicit consideration of the potential place of partnership within undergraduate research and inquiry might prove valuable for researchers interested in advancing the notion of "students as scholars." Existing hierarchies and role expectations, so commonly discussed in the partnership literature, could be considered more thoroughly in undergraduate research and inquiry, as could the experiences of and benefits for faculty engaged in such work.

References

Allin, Linda. 2014. "Collaboration between Staff and Students in the Scholarship of Teaching and Learning: The Potential and the Problems." *Teaching & Learning Inquiry* 2(1): 95–102. doi: 10.2979/teachlearninqu.2.1.95

Bovill, Catherine, Alison Cook-Sather, Peter Felten, Luke Millard, and Niamh Moore-Cherry. 2016. "Addressing Potential Challenges in Co-creating Learning and Teaching: Overcoming Resistance, Navigating Institutional Norms and Ensuring Inclusivity in Student-Staff Partnerships." *Higher Education* 71: 195–208. doi: 10.1007/s10734-015-9896-4

Brew, Angela. 2006. *Research and Teaching: Beyond the Divide*. Houndsmills, UK: Palgrave.

Cook-Sather, Alison. 2014. "Student-Faculty Partnership in Explorations of Pedagogical Practice: A Threshold Concept in Academic Development." *International Journal for Academic Development* 19: 186–198. doi: 10.1080/1360144x.2013.805694

Cook-Sather, Alison, and Alia Luz. 2015. "Greater Engagement in and Responsibility for Learning: What Happens When Students Cross the Threshold of Student-Faculty Partnership." *Higher Education Research & Development* 34: 1097–1109. doi: 10.1080/07294360.2014.911263

Cook-Sather, Alison, Catherine Bovill, and Peter Felten. 2014. *Engaging Students as Partners in Learning and Teaching: A Guide for Faculty*. San Francisco: Jossey-Bass.

Cuneo, Carl, Del Harnish, Dale Roy, and Susan Vajoczki. 2012. "Lessons Learned: The McMaster Inquiry Story from Innovation to Institutionalization." *New Directions for Teaching and Learning* 129: 93–104. doi: 10.1002/tl.20010

Curley, Melissa, and Andreas Schloenhardt. 2014. "Undergraduate Research and Human Rights: An Australian Case Study on Human Trafficking and Migrant Smuggling." *CUR Quarterly* 34(3): 24–29.

Felten, Peter, Julianne Bagg, Michael Bumbry, Jennifer Hill, Karen Hornsby, Maria Pratt, and Saranne Weller. 2013. "A Call for Expanding Inclusive Student Engagement in SoTL." *Teaching and Learning Inquiry* 1(2): 63–74. doi: 10.20343/teachlearninqu.1.2.63

Forward with Integrity Advisory Group. 2012. "Forward with Integrity: The Emerging Landscape." Accessed January 24, 2017. http://president.mcmaster.ca/reports/fwi/

Healey, Mick, Abbi Flint, and Kathy Harrington. 2014. *Engagement through Partnership: Students as Partners in Learning and Teaching in Higher Education*. York, UK: Higher Education Academy. https://www.heacademy.ac.uk/engagement-through-partnership-students-partners-learning-and-teaching-higher-education. doi: 10.1080/1360144x.2016.1124966

Healey, Mick, and Alan Jenkins. 2009. *Developing Undergraduate Research and Inquiry*. York, UK: Higher Education Academy. https://www.heacademy.ac.uk/resource/developing-undergraduate-research-and-inquiry

Hodge, David C., Marjorie Nadler, Cecilia Shore, and Beverley Taylor. 2011. "Institutionalizing Large-Scale Curricular Change: The Top 25 Project at Miami University." *Change* 43(5): 28–35. doi: 10.1080/00091383.2011.599290

Jenkins, Herb, Barbara Ferrier, and Michael L. Ross (Eds.). 2004. *Combining Two Cultures: McMaster University's Arts and Science Program*. Lanham, MD: University Press of America.

Justice, Christopher, James Rice, Dale Roy, Bob Hudspith, and Herb Jenkins. 2009. "Inquiry-Based Learning in Higher Education: Administrators' Perspectives on Integrating Inquiry Pedagogy into the Curriculum." *Higher Education* 58: 841–855. doi: 10.1007/s10734-009-9228-7

Levy, Philippa. 2011. "Embedding Inquiry and Research into Mainstream Higher Education: A UK Perspective." *CUR Quarterly* 32(1): 36-42.

Levy, Philippa, Sabine Little, and Natalie Whelan. 2011. "Perspectives on Staff-Student Partnership in Learning, Research and Educational Enhancement." In *Staff-Student Partnerships in Higher Education*, ed. Sabine Little, 1–15. New York: Continuum.

Little, Sabine (Ed). 2011. *Staff-Student Partnerships in Higher Education*. New York: Continuum.

Marquis, Elizabeth, Varun Puri, Stephanie Wan, Arshad Ahmad, Lori Goff, Kris Knorr, Ianitza Vassileva, and Jason Woo. 2016. "Navigating the Threshold of Student-Staff Partnerships: A Case Study from an Ontario Teaching and Learning Institute." *International Journal for Academic Development* 21(4): 4–15. doi: 10.1080/1360144x.2015.1113538

Marquis, Elizabeth, Zeeshan Haqqee, Sabrina Kirby, Alexandra Liu, Robert Cockcroft, Lori Goff, and Kris Knorr. Forthcoming.

"Connecting Students and Staff for Teaching and Learning Inquiry: The McMaster Student Partners Program." In *Disciplinary Approaches to Connecting the Higher Education Curriculum*, ed. Brent Carnell and Dilly Fung. London: UCL Press.

McCulloch, Alistair. 2009. "The Student as Co-Producer: Learning from Public Administration about the Student-University Relationship." *Studies in Higher Education* 34: 171–183. doi: 10.1080/03075070802562857

Meyer, Jan H. F., and Ray Land (Eds.). 2006. *Overcoming Barriers to Student Understanding: Threshold Concepts and Troublesome Knowledge*. London: Routledge.

Neary, Mike. 2014. "Student as Producer: Research-Engaged Teaching Frames University-Wide Curriculum Development." *CUR Quarterly* 35(2): 28–34.

Shanahan, Jenny Olin, Elizabeth Ackley-Holbrook, Eric Hall, Kearsley Stewart, and Helen Walkington. 2015. "Ten Salient Practices of Undergraduate Research Mentors: A Review of the Literature." *Mentoring & Tutoring: Partnership in Learning* 23: 359–376. doi: 10.1080/13611267.2015.1126162

Vajoczki, Susan. 2010. "A Canadian Perspective on Undergraduate Research." *CUR Quarterly* 31(2): 41–47.

Werder, Carmen, and Megan M. Otis (Eds.). 2010. *Engaging Student Voices in the Study of Teaching and Learning*. Sterling, VA: Stylus.

Elizabeth Marquis
McMaster University, beth.marquis@mcmaster.ca

Beth Marquis is an assistant professor in the Arts & Science Program at McMaster University and associate director (research) at the Paul R. MacPherson Institute for Innovation, Leadership, and Excellence in Teaching. She serves as senior editor of the Canadian Journal for the Scholarship of Teaching and Learning, *and is co-president-elect of the International Society for the Scholarship of Teaching & Learning (ISSOTL). Marquis's SoTL research focuses on the intersections between teaching and learning and questions of equity and justice, and on film and media texts as public pedagogy. She is also committed to supporting and researching student-staff partnerships in higher education and oversees McMaster's Student Partners Program.*

THEORY

Making Inquiry Learning Our Top Priority: Why We Must and How We Can

Carol Geary Schneider, *Lumina Foundation*

Abstract

The liberal arts of evidence-based inquiry are necessities for knowledgeable participation in a self-governing democracy and equally important in an innovation-dependent economy. Higher education's role in fostering these capacities has always been one of its most important contributions to the greater good. The current political environment calls for a new sense of urgency about preparing graduates to apply evidence-based reasoning to complex questions and competing claims. Yet a new study of students' course-based assignments suggests that large numbers of college seniors are leaving college with a very weak grasp of how to use evidence or build a well-supported argument. Calling on educators to make the shift from "my course" to new intentionality about "our curriculum," the author provides practical suggestions for fostering the skills foundational to inquiry learning from first to final year.

Keywords: *critical thinking; education outcomes; high-impact practices; inquiry-based learning*

doi: 10.18833/spur/1/1/10

Since you're reading this inaugural issue of SPUR, you're likely already convinced of the importance of undergraduate research. Sharing that conviction, I write here to urge you to now make it a top priority, not just to do a good job with those students who make their way into the research and inquiry learning zone, but to expand that inquiry learning zone until it includes every college student, whatever their interests, and whatever their background and preparation.

Today, we know from the National Study of Student Engagement (NSSE 2016) that about 45 percent of graduating seniors complete a "capstone project," which likely involves some kind of inquiry, writing, and/or another form of creative expression such as multimedia. My argument in this essay is that *all* students should both prepare for and participate in this kind of inquiry-framed culminating experience as a necessary part of their college studies. Whether students are headed for the world of work or further learning, their preparation for these culminating projects should, without exception, include schooling in the basics of research: problem framing, evidence-based inquiry, and engagement with multiple forms of evidence analysis and interpretation—both qualitative and quantitative.

In addition, to develop skills in evidence-based inquiry, *all* students should participate, every semester and every year, in complex assignments where they must grapple with the deployment of evidence—evidence drawn from other people's work, evidence drawn from their own inquiry learning, and evidence informed by experiences in negotiating the actual meaning and significance of findings with people whose views and standpoints are different from their own.

I urge you to provide strong leadership for inquiry-framed learning for two reasons. First, the capacity to make good use of evidence in tackling complex questions is *necessary* learning for a self-governing democracy in which "we the people" weigh in to make decisions about both leaders and policy choices. Similarly, the capacity to engage constructively with people, views, and values different from our own is a fundamental capability in a pluralist democracy. And yet, commitment to the importance of evidence has recently become endangered in U.S. society.

Moreover, the whole concept of constructively and respectfully engaging diversity is, once again, under societal siege. Higher education needs to provide vocal and substantive leadership on these issues as our society works through them. More on that below.

Second, although higher education clearly should play a distinctive role in helping citizens hone the capacity to bring evidence and diverse perspectives to bear on complex questions, recent research indicates that higher education is falling significantly short of the mark in what is surely one of our most foundational responsibilities. New evidence on that front will be shared below as well.

If our society is to grapple successfully with complex questions, we need to promote, model, and teach the kind of mind-set required for complex decision-making. Crucially, we need to help our students do better. My work with educational reform over the past decades persuades me that a key way to "do better" is to involve students, early and often, in inquiry-based exploration of questions that matter, both to the students and to the wider society. This, in turn, will require a newly collaborative approach to the educational work of all postsecondary institutions. I provide some guiding premises for this work in the final part of this essay.

My Journey to Inquiry-Based Learning

As AAC&U senior scholar Lee Knefelkamp (1990) reminds us, all educational thinking tends to be autobiographical. With this in mind, a brief review of my own history and experience with undergraduate research may help to clarify the assumptions and experiences that do—and do not—stand behind the proposals in this essay.

As a high school student and a Mount Holyoke College undergraduate, I did copious amounts of research. This began with a high school Advanced Placement course in American history, which included a long paper based on primary sources, and continued through to a thesis on Thomas More and Christian humanism in my final year of college.

I never did any of this work as part of a faculty member's research team. My research papers were almost all written to meet course assignments and expectations, both within and beyond my history major, an experience that strongly influences my belief that regular course assignments can and should build inquiry competence. The expectations for my "research productivity" seemed to grow markedly across my four years of college so that, in my junior year alone, I turned in more than 200 pages of completed writing, most of it in the form of 20–30 page research papers and a separate set of shorter literature reviews. In addition, anticipating my senior thesis and feeling anxious about my ability to succeed in such a big project, I also undertook a credit-bearing "independent study" in my sophomore year.

A lot of this research was not, in fact, very good, especially the work from my first two years of college. Much of my early college work was descriptive and derivative rather than analytical or insightful. Nonetheless, constant practice did build skill, and my senior thesis was a creditable piece of work, grounded in the writings of More and Erasmus, informed by mentored independent reading in Plato (a major influence on Christian humanists), and enriched by a deep dive into the extensive and conflicting secondary literature on my subjects.

What did I gain from these efforts? By the time I graduated from college, I was already well aware that I had internalized a strong sense of the difference between really knowing what I was talking about on a complicated topic and "just winging it" with quickly acquired and unexamined opinion. That knowledge has stood me in good stead over a long career. It was, among other benefits, a critically important job skill. Not least, it inclined me toward an extended family of colleagues and fellow leaders whose own expert knowledge on specific topics could complement and supplement the unavoidable limits on my own (or any single person's) deep learning bandwidth.

My acquired disinclination to "just winging it" also has helped me as a citizen. We cannot all be experts on every subject. But we can develop working criteria for the professed expertise of others. We can ask of public leaders what Mount Holyoke and (later) Harvard University asked of me: a commitment to deep engagement with complexity and a resistance to shallow, once-over-lightly opinion.

Much as I value what I gained from my education, when I propose that every student should prepare for and participate in a significant inquiry-based learning project, my own highly academic training is decidedly *not* what I have in mind. The kind of pre–graduate school apprenticeship I experienced in college is appropriate for some students but surely not for all or even most.

What I do have in mind is students' constant engagement with—and evidence-based writing about—unscripted questions—questions where the right answer is not known and where students will have to do significant work to develop a reasoned and evidence-supported judgment. Optimally, many of these assignments will involve questions that interest the student actually doing the work and problems whose significance the student will learn to clarify for others. Inevitably, many of these questions will involve controversies about the best course of action, with some of these controversies inflected—directly (through studies of social change) or implicitly (through the dynamics of a lab, workgroup, or social media)—by issues of power, identity, and equity.

These commitments to inquiry-based learning and the practices that help students master it were front and center during my most far-reaching work as president of AAC&U: the long-term and still-continuing Liberal Education and America's Promise initiative (LEAP; AAC&U 2015) to provide a contemporary guiding vision for liberal education in a complex global world. LEAP focuses on a set of "essential learning outcomes"—such as critical thinking, problem-solving, intercultural learning, ethical reasoning, and communicating—that are important in every field of endeavor, from the workplace to democratic community and scholarship.

LEAP also helped develop and promulgate evidence that students are most likely to develop these essential capacities when they participate frequently in hands-on educational experiences—first-year seminars, research experiences, writing-intensive courses, collaborative projects, diversity learning, senior capstones, and the like—that require them to grapple with complex questions and with competing perspectives on those questions.

Since 2007, these kinds of hands-on inquiry learning experiences have been recognized as high-impact practices or HIPs. Evidence from NSSE gathered over the past decade shows compellingly that when students participate in HIPs, they are more likely to make progress on expected learning outcomes, and more likely to persist in and complete their college studies (Kuh 2008; Brownell and Swaner 2010; Kuh, O'Donnell, and Schneider 2017). Other studies show that the more frequently students participate in HIPs, the better the results, again both for completion and deep learning (Finley and McNair 2013).

Space does not permit a recapitulation here of the large and growing literature on HIPs. My argument here is that inquiry-based learning, grounded in recurrent engagement with evidence and diverse perspectives on the meaning of evidence, can give purpose and focus to educators' use of HIPs, including undergraduate research, to increase both students' persistence in college and achievement of essential learning outcomes.

Rather than seeing participation in various HIPs as a new set of boxes for students to "check off," we can stage those experiences in ways that build students' meaningful engagement with questions they care about and that prepare them for the culminating HIP: completion of capstone work that reflects and expresses their development as capable, inquiry-centered learners. AAC&U has incorporated this concept in its ongoing LEAP campaign through the recently released *LEAP Challenge*: a call to include multiple experiences with HIPs and a culminating signature work experience in every student's journey through college (AAC&U 2015; Schneider 2015; Peden, Reed, and Wolfe 2017).

Whereas today slightly less than half of all students report doing culminating work in their final year, *The LEAP Challenge* invites higher education to make such projects the new standard for quality college learning. The term *signature* signals that, in this effort, students will take ownership of their work, choosing topics they care about and preparing to share the fruits of their work with others.

Although the concept of a culminating inquiry project for all students may seem a daunting reach today, adopting this reform would in fact accelerate a trend toward involving students in "capstone" work that has been visible for more than two decades across all parts of higher education (Schneider 2004, 2015). It would also bring energy to yet another discernible education trend: campus efforts to help students integrate the different aspects of their college study: broad and specialized learning, experiential and formal learning, and intellectual skills deployed "across-the-curriculum."

Research on campus educational priorities shows that the majority of postsecondary institutions already are working to provide more integrative forms of college learning for today's students (Hart Research Associates 2015a). Expecting and preparing college students to tackle a complex inquiry question or problem in a senior project would bring new educational and organizational focus to this work on integrative learning. Moreover, if faculty and advisers bring students' own questions and interests directly into their educational preparation for capstone work, integrative inquiry learning can become motivating to students themselves, because it will focus by design on issues that students really want to engage and explore (Schneider 2016).

Employers strongly endorse the idea that students should do significant projects as undergraduates. Some 73 percent of employers recently indicated that requiring students to do a significant project would improve their preparation for careers. Moreover, 87 percent of employers indicated that they would be more likely to hire a student who had completed "an advanced, comprehensive project in senior year, such as a thesis, senior project or other major assignment that requires the student to demonstrate depth of knowledge in their major AND their acquisition of research, problem-solving, and communication skills" (Hart Research Associates 2015b, emphasis in original).

The New Urgency Around Using Evidence

As the discussion here makes clear, my commitment to the value of evidence-based inquiry is long-standing and rooted in emerging findings about "what works" educationally for today's students. What is new today, however, is my dramatically heightened sense of civic urgency about the need to move students' engagement with inquiry, evidence, and diverse perspectives to the very top of the higher education reform agenda.

The first driver for this new urgency is the suddenly fierce debate in our society over what seems an almost surreal issue: the question of whether our public policy choices will be anchored in evidence or whether they will be driven by arbitrary assertions that run counter, not only to prevailing expert judgment but also to decades of persuasive quantitative data. Here are just three examples from dozens that might be cited: the willful denial, at the highest levels of our government, of the prevailing consensus on global warming and its increasingly evident deleterious consequences; federal policy, again at the highest levels of government, that presumes a crisis in law enforcement when reported crime levels are actually at all-time lows over the past quarter century; or the claim that deep tax cuts will be new revenue generators when three decades of earlier experiments with this idea show that a deep cut in taxes invariably results in deeper deficits. In each of these instances, the "facts" run directly counter to leaders' political priorities. Yet in the roiling world of U.S. politics, such inconvenient truths are very readily dismissed while the "elites" who keep insisting on evidence are themselves assailed as untrustworthy.

There is even a new term for this phenomenon: national leaders who dismiss expert findings are being guided instead by "alternative facts." Arrestingly, almost as soon as the notion of "alternative facts" went viral in late January 2017, CNN reported that George Orwell's *1984*, which deals with the distortion of language in a dystopian regime, had surged unexpectedly to the top of Amazon's computer-generated bestseller list.

Clearly, many are alert to the dangerous assault on evidence. And yet, as one analyst has observed in commentary about similar developments in France, disruptive leaders operate freely in this new zone of "alternative facts" because "it works: Voters today don't read long analyses," this analyst notes, "they remember forceful assertions" (Daoud 2017). Indeed, if baseless but forceful assertions are made with enough frequency, the strategy simply overwhelms fact-checking or follow-up on what actually happened. The public registers the strong assertion of a position. The fact-free position, stated with sufficient frequency, becomes "normalized." Only the dogged take the trouble to discern the disconnect among assertion, evidence, and long-term impact. Their investigations have little effect in correcting the dominant narrative.

Self-evidently, the whole concept of choosing one's own facts flies directly in the face of higher education's most fundamental commitments: to the honest search for new and verifiable knowledge and to the multifaceted examination of difficult questions where values and diverse contexts necessarily influence what we come to hold as knowledge. Yet it is all too easy in our contemporary context where "elites" are perceived as the problem for leaders to despair of any hope that we can educate fellow citizens to prefer complexity and to resist simplistic assertions and invented "information." Rather, educators are being told it is time to listen with new attentiveness to those who have been left behind, both from opportunity and a solid education, so that we ourselves can learn with new humility.

This is indeed a time for thoughtful reassessment by everyone who cares about the future of democracy. But it is also a time for recommitting to core values and for asking how we can better align our practices with those values.

Whatever our current political travails and soul-searching, higher education is today, and always has been, a dedicated space where scholars, leaders, and learners come together to explore complexity and to seek the kind of knowledge that helps build a better world. We cannot retreat from this mission; we must band together both to forcefully reaffirm it and to expand our communities so that ever larger numbers of students can benefit from the empowerment provided by inquiry learning. And, as I suggested in the first part of this essay, we can expand our conception of "questions that matter" so that community concerns and our own students' concerns become catalysts for deep inquiry as well as collaborative, inclusive, and generative problem-solving.

Evidence matters, we must vigorously affirm, and higher education's two most fundamental obligations are to advance the search for evidence-based understanding and to help learners develop their own capacities for reasoned judgment in the face of complexity. These are democracy fundamentals which are equally needed in an innovation-fueled knowledge economy.

The work we do best is everyone's best hope for a better future. We need to proclaim, expand, and enact that conviction. At all levels—from the boardroom to the classroom, in person and via social media—we need to see a new, concerted affirmation from higher education that the advancement of knowledge through evidence-based inquiry is foundational to a great democracy and that we play a special and irreplaceable role, both in teaching students (and future scholars) how to evaluate competing knowledge claims and in teaching respect for the importance of diverse voices and perspectives in all such evaluation.

To Our Peril, Today's Students Are Falling Short on Inquiry Skills

Thus far, I have argued the following: evidence matters. It is indispensable to virtually any question we aim to solve. Higher education leaders need to profess and proclaim our special role in helping students develop both the capacity and the commitment to deploy evidence from diverse sources and to engage differing perspectives on the meaning of evidence.

Research experiences are part of this special role. But so, too, are other forms of learning: inquiry seminars; linked courses in which students explore a complex topic across different disciplines and assignments; field-based learning; collaborative projects; diversity and global experiences; creative work and collaborations; and ePortfolios that foster reflection as well as synthesis of students' learning over time (Kuh 2017; Eynon and Gambino 2017). We can and must foreground and showcase the multiple forms of inquiry-based learning that prepare students to contribute both as citizens and in a fast-changing workplace.

Yet even as we rally to reaffirm the importance of inquiry learning, there is a second driver behind my proposal that inquiry learning needs to become higher education's most urgent priority: specifically, the mounting evidence that large numbers of graduating students are falling well short of the mark when it comes to critical inquiry, the analysis of evidence, and the engagement of diverse perspectives in the interpretation of evidence. Committed though higher education may be to inquiry as its most important public good, new research shows that students are significantly underperforming on core skills—including the use of evidence and engagement with diverse perspectives—that are foundational to critical inquiry. This would be bad news at any time. It is especially bad news at a moment when the nation sorely needs all the talent it can bring to creating evidence-based solutions to pressing public and economic problems.

Until very recently, the only national studies of college students' prowess with critical thinking skills were based on standardized tests that have been disconnected by design from the work done by students in the context of their day-to-day college courses. Today, however, higher education has new assessment tools that allow a deep dive into evidence drawn directly from students' completed course assignments about their skills in the learning outcomes that most educators will agree are "essential." For the first time, we are poised to form judgments about students' achievement levels based not on tests that are disconnected from the curriculum but directly on work they initially completed to earn course grades.

This assessment strategy is called Valid Assessment of Learning in Undergraduate Education (VALUE; AAC&U 2017b). The tools are VALUE rubrics, which are keyed to 16 widely endorsed goals for college learning, ranging from the most obvious (such as critical thinking, communication, or quantitative reasoning) to less commonly studied outcomes (such as problem-solving, intercultural learning, ethical reasoning, integrative learning, and global learning). Created to help educators assess student progress on the LEAP Essential Learning Outcomes, the rubrics were initially developed through grants from the Fund for the Improvement of Postsecondary Education of the U.S. Department of Education and State Farm Companies Foundation.

The VALUE rubrics are the work of faculty teams from all parts of higher education, including experts in each of the learning outcomes being assessed. The rubrics were validated by other faculty members, who used initial and revised versions of the rubrics to assess samples of student work drawn from across the curriculum. The advantage of this approach to assessment over standardized tests is that faculty members using it become directly engaged with the question whether the assignments being given to students are really appropriate to help foster the capacities we believe students need to achieve. The VALUE approach helps shift faculty attention away from "what I do in my course" to how well "our curriculum" is actually fostering essential learning outcomes.

Initially, the VALUE rubrics were used campus by campus or even department by department, making it difficult to draw more general insights about student progress from these assessments. Today, however, there is an organized effort across higher education to develop VALUE assessments systemically, using trained faculty scorers, common rules for choosing assignments that are appropriate for the learning outcomes under review, and a national digital platform through which faculty can assess the levels of demonstrated skills in student assignments from campuses other than their own. Altogether, there are nearly 100 institutions—public and private, two- and four-year—involved in the ongoing national VALUE study.

This demonstration VALUE study is the result of several years of collaboration among AAC&U, the State Higher Education Executive Officers Association (SHEEO), the Multi-State Collaborative to Advance Quality Student Learning (MSC) that now includes 13 state systems or coordinating boards, the Great Lakes Colleges Association (GLCA), and a Minnesota Collaborative that involves public and private higher education institutions. The current funding for this effort has come from multiple sources, including the Bill and Melinda Gates Foundation, the Spencer Foundation, the Sherman Fairchild Foundation, and Lumina Foundation.

This ongoing effort has released two sets of findings, one in 2015 from a pilot year, undertaken to test protocols for the study, and a second set in spring 2017 from the so-called demonstration year. Findings from the pilot-year study can be found at http://www.aacu.org/press/press-releases/multi-state-collaboration-produces-valuable-new-evidence-about-writing-critical. The demonstration-year results are reported in detail in *On Solid Ground: A Preliminary Look at the Quality of Student Learning in the United States* (AAC&U 2017a). Additional aspects of the study are reported by SHEEO (2017).

In what follows, I call readers' attention to the 2017 findings reported by the MSC—the largest group of two- and four-year institutions in the VALUE study—for student achievement in critical thinking and especially its five components: (l) the student's explanation of issues, (2) use of evidence, (3) ability to engage the context/assumptions embedded in the issue being explored—in effect, how well both context and multiple perspectives are engaged in the issue under study, (4) position (perspective, thesis, hypothesis); and (5) development of conclusions/outcomes based on an analysis of both evidence and perspectives. The findings come from 34 public two-year colleges and 41 public four-year institutions, including public research universities.

The assignments used to reach conclusions on critical thinking capacities were drawn from students who had completed three quarters of their degree program—more than 45 hours at the associate level or more than 90 hours at the baccalaureate level. The faculty members who evaluated those assignments had undergone training to ensure consistency and reliability in their application of the relevant VALUE rubrics. The assignments came from a broad range of disciplines, and all scorers came from institutions other than the students' home campus.

The results for college seniors (based on 2056 samples of student work drawn from institutions in 12 states) reveal that only a few of their assignments were scored at level 4—that is, met the "capstone level" of proficiency on the VALUE rubric for specific dimensions of critical thinking. Here are the findings on assignments that met level 4 standards for different aspects of critical thinking:

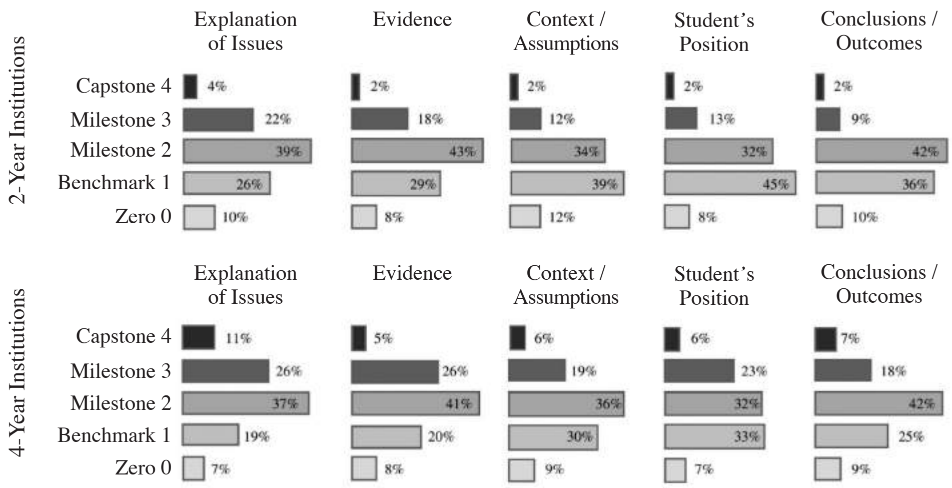
- 11 percent on explanation of issues,
- 5 percent on use of evidence,
- 6 percent on context/assumptions,
- 6 percent on position (perspective; thesis; hypothesis), and
- 7 percent on conclusions/outcomes (see Figure 1).

If the scores of seniors who reached either level 3 or level 4 on these component dimensions of critical thinking are added together, the results show that only a third or fewer of the assignments demonstrated proficiency at level 3 or level 4 for the components of critical thinking shown in Figure 1 except explanation of issues.

Moreover, the two-year scores—all drawn from students in community colleges who had completed more than 45 hours—reveal that approximately half to two-thirds of the two-year students are scoring at or above level 2, whereas two-thirds to three-quarters of the seniors are not reaching even level 3 on any aspect of critical thinking except explanation of issues (see Figure 1). This raises the question whether the assignments that students receive in their final two years are really aiming at higher level intellectual skills. VALUE leaders are currently probing this critical question (AAC&U Vice President Terrel Rhodes, email message to author, May 2017).

Seniors did somewhat better against the VALUE rubric for communication (AAC&U 2017a, 39), with half or more reaching at least level 3 on most dimensions of the

FIGURE 1. Critical Thinking



Note: Assignments scored for the VALUE study came from students who completed 75% of their studies for the associate degree or for the bachelor's degree. The assignments came from a broad range of courses and disciplines. Figure reprinted with permission from *On Solid Ground*, copyright © 2017 by the Association of American Colleges and Universities.

learning outcome. But here, too, the results indicate that many of students are not reaching expected standards of proficiency when it comes to the use of sources/evidence. Only 13 percent of senior assignments scored for this study reached level 4 on the dimension of sources/evidence, with another 29 percent reaching level 3.

In other words, the assignments initially submitted by these students for course grades showed that nearly 6 in 10 seniors were at a preliminary level only in their capacity to use evidence in the context of a written communication.

Leaders of the VALUE project caution that these findings should not be generalized beyond the institutions in the VALUE studies—in this case, the 75 institutions participating in the MSC collaborative (AAC&U 2017a, 33). Even with that stipulation, the VALUE results are nonetheless sobering. Research conducted for AAC&U in 2015 shows that fully 98 percent of member institutions have made critical thinking one of their expected learning outcomes, with 99 percent also making communication one of their core expectations for student achievement (Hart Research Associates 2015a). Other research shows that employers consider critical thinking one of the basics for success in the workplace (e.g., Hart Research 2015b). Moreover, as argued above, evidence-based thinking is equally fundamental in a self-governing democracy. Yet the evidence drawn from students' own work shows that too many graduating students are not reaching the expected inquiry-learning proficiency.

In a way, these findings should not be surprising. Survey research shows that employers also give recent graduates low marks on such fundamentals as critical thinking, communication, and diversity acumen (Hart Research Associates 2015a). But most faculty members do not view employers as the ultimate source of evidence on the quality of student learning. In the VALUE study, findings have been produced by faculty members themselves based on assignments initially prepared to fulfill course requirements.

What the VALUE evidence shows is a troubling distance between the aspirations of higher education and the actual outcomes for students. To serve both students and society, educators must close that gap.

How to Address the Inquiry Learning Gap

What, then, do we do? Higher education's commitment to inquiry—both as scholarship and as a critical dimension of student learning—needs not just vigorous reaffirmation but a comprehensive and determined "do-over."

That do-over should begin, I suggest, with a new focus on collaborative planning–informed by local assessments of students' authentic work—to ensure that the courses taught really do engage students, early and often, and at progressively more challenging levels, in assignments that *require* the component elements of inquiry learning: framing a question, engaging diverse perspectives drawn from different contexts on that question, examining and/or developing evidence, making an evidence-based judgment, and examining the limitations or likely dissents to a personal position.

The general idea is that faculty responsible for a program of study can and should ensure that regular course assignments in that program do the following:

1. engage the student with significant questions that matter to the student as well as to others;
2. establish engagement with inquiry and evidence as essential;
3. help each student develop the capacity and the commitment to engage both diverse perspectives and the value of evidence in tackling complex questions; and
4. enable students to take ownership of their own learning, in full understanding that continued learning will be absolutely necessary in all parts of their lives—as employees in the workplace, as residents of a community, and as resilient human beings.

This does not mean that every course needs to address every expected learning outcome or every component of a complex learning outcome such as critical thinking or communication. But it does mean that every faculty member and student should know where, when, and how students will work across different courses to develop the multiple capacities necessary to engage in inquiry, analysis, invention, problem-solving, and communication. This is by no means a constraint on course content or teaching approaches to that content. But it does call for a new degree of intentionality about ensuring, across multiple courses, that students will complete content-appropriate intellectual tasks related to the different elements of inquiry learning.

As both my own experience in college and the results of the VALUE study suggest, assignments are the critical key to students' development of proficiency. When the assignments are weak or when, in a misplaced expression of "academic freedom," a course includes no assignments at all, the chance that students will become proficient in complex analysis is remote. Thus assignments need to be collaboratively and intentionally planned, with faculty members helping one another—and consulting national research—on the kinds of activities that help students become proficient inquiry learners.

Today, on virtually every campus, course assignments remain each faculty member's private decision. This is the Achilles heel that frustrates achievement of our highest educational purposes.

Making assignments a form of community property is likely the most important thing we can do to ensure that students have equitable access to inquiry learning experiences and guided development of their most important intellectual skills. As previously mentioned, the ultimate assignment should be the student's capstone or signature work—a complex project, taking at least a semester to complete, that reflects each student's interests and developed ability to bring inquiry skills and judgment to the final project.

Table 1 provides a curriculum "map" that shows how faculty together can plan for, and help students prepare for, both proficiency in inquiry learning and completion of a capstone or signature work project. The "map," which has been amended from a model freely available on the web, shows where and how often students would practice specific inquiry capacities in the context of their study in a particular academic area. The map could be further amended to track general education goals and practices from first to final year.

What needs to be stressed, however, is that this "map" remains a profile, an outline. It will come to educational "life" only when faculty reach shared agreement on the kinds of assignments that will successfully build both the discipline-specific learning they value in their programs and the capacity to use cross-cutting skills such as evaluating evidence or engaging/applying diverse perspectives in ways appropriate to the field of study.

I am mindful that many faculty teach so many students in a given semester that they consider it impossible to give robust assignments or even examinations that go beyond multiple-choice responses. I am also mindful that many faculty members teach "outside" any meaningful curriculum dialogue because they are adjunct rather than full-time members of the community.

These are significant but not insurmountable obstacles. They seem impossible mainly because typical campus practice leaves each faculty member essentially on his or her own to determine his or her role in fostering students' intellectual development.

Even in large courses, there are many things faculty can do to involve students in inquiry learning assignments. For example, they can offer collaborative rather than individual student projects; enlist well-prepared advanced students as undergraduate learning assistants to coach novice students in inquiry and problem-solving strategies (Ehrmann 2017); or provide flipped classrooms, in which students review lecture materials in advance and work actively together on mini-assignments in class. José Bowen and C. Edward Watson's *Teaching Naked Techniques* (2017) provides a rich family of examples drawn from faculty members teaching in all kinds of institutions across the United States. Its discussion of "integrative learning" is especially useful to those engaged in program planning that fosters deeper student engagement in inquiry learning.

For adjuncts, the curriculum mapping exercise illustrated in Table 1 can be especially useful to their teaching, even if they are not available to take part in the mapping exercise. Seeing—via a program curriculum map—how their courses fit into a larger educational trajectory brings part-time faculty into a shared community of practice. Knowing the kinds of assignments expected in their particular course(s) frees adjuncts from the isolated exercise of deciding almost entirely on their own how much they should ask of their students. Once the program itself becomes highly intentional, adjuncts can see far better how "my course" fits into "our curriculum" and their own role in the students' development as inquiry-proficient learners.

My main recommendation here is that members need to *work together* on mapping inquiry learning across the educational trajectory instead of leaving each faculty member to do his or her best in the absence of any shared planning. Conceivably, faculty will come to a consensus that some courses will be content heavy with few or no assignments beyond examinations. But they also need to organize their collective time so that every program includes *sequences of learning activities*, from first to final level, that ensure students' equitable access to quality assignments designed to take them to high levels of proficiency on all the components of evidence-based reasoning. Most institutions still distinguish, on the books, between 100-level courses, 200-level courses, and so on. The question to ask is what kind of assignments should be done by students at each level so that, whatever content they study, all will build skill both in the basics of inquiry and in the translation of their own questions into meaningful projects.

The curriculum map in Table 1 can open faculty discussions. But the larger goal is a curriculum design that is regularly revisited to determine its effectiveness. The work produced by students for their assignments, including their culminating assignments, will show faculty what is working and what still needs amendment.

This kind of faculty collaboration becomes even more important in considering the impact of digital innovation on mainstream higher educational practice. It is clear that the digital revolution has already significantly changed the way many students learn and that the future will bring new combinations of digitally supported, face-to-face, and blended forms of learning. The question to pursue now (a form of inquiry learning in its own right) is how faculty can use digital platforms to help free up time and space so they can help students build the knowledge, skills, and mentored experiences needed to deal successfully with unscripted, open-ended problems (Bass and Eynon 2016).

TABLE 1. Curriculum Mapping for Essential Learning Outcomes and Signature Inquiry-Learning Projects

	Introductory course	Research methods	Advanced content course A	Laboratory/ practicum	Advanced content course B	Advanced content course C	Advanced content course D	Capstone work
Content								
SLO 1: Disciplinary knowledge base (models and theories)	Introduced		Reinforced		Reinforced	Reinforced	Reinforced	Mastery/Assessed
SLO 2: Disciplinary methods		Introduced		Reinforced		Reinforced		Mastery/Assessed
SLO 3: Disciplinary applications	Introduced		Reinforced		Reinforced		Reinforced	Mastery/Assessed
Critical Thinking								
SLO 4: Analysis, evaluation, and use of evidence		Introduced		Reinforced	Reinforced		Reinforced	Mastery/Assessed
SLO 5: Engaging and applying diverse perspectives	Introduced	Reinforced		Reinforced		Reinforced		Mastery/Assessed
Communication								
SLO 6: Written communication skills	Introduced	Reinforced		Reinforced		Reinforced		Mastery/Assessed
SLO 7: Oral communication skills		Introduced	Reinforced		Reinforced	Mastery/ Assessed		
Integrity/Values								
SLO 8: Academic and disciplinary ethical standards			Introduced		Reinforced	Reinforced		Mastery/Assessed
SLO 9: Responsibilities to society	Introduced	Reinforced	Reinforced	Reinforced		Reinforced		Mastery/Assessed
Signature Project								
SLO 10: Problem-centered inquiry and project development		Introduced		Reinforced	Reinforced	Reinforced	Reinforced	Mastery/Assessed
SLO 11: Working with diverse partners	Introduced	Reinforced			Reinforced		Reinforced	Mastery/Assessed
SLO 12: Self-regulation and metacognitive skills	Introduced			Reinforced	Reinforced	Reinforced		Mastery/Assessed

Note: This map is based on a model provided by the Center for University Teaching, Learning, and Assessment at the University of West Florida (http://uwf.edu/cutla). It was adapted to align both with the AAC&U LEAP Essential Learning Outcomes and with Lumina Foundation's Degree Qualifications Profile (DQP).

Mentoring student work is time-consuming and challenging. Faculty need to ask, therefore, how digital platforms and cognitive tutorials can be employed to release them from such tasks as lecturing so that time can be reassigned to the kinds of learning from which students will gain the most long-term value.

These are not simple questions, but this is the time to ask and answer them. Higher education must rally to ensure that it provides more—and more empowering—inquiry learning for today's students. Anything less will shortchange our students and deplete democracy's future.

References

Association of American Colleges and Universities. 2015. *The LEAP Challenge: Education for a World of Unscripted Problems*. Washington, DC: Author.

Association of American Colleges and Universities. 2017a. *On Solid Ground: A Preliminary Look at the Quality of Student Learning in the United States*. Washington, DC: Author. Accessed April 1, 2017. http://www.aacu.org/OnSolidGroundVALUE

Association of American Colleges and Universities. 2017b. *VALUE*. Washington, DC: Author. Accessed July 28, 2017. http://www.aacu.org/value

Bass, Randy, and Bret Eynon. 2016. *Open and Integrative: Designing Liberal Education for the New Digital Ecosystem*. Washington, DC: Association of American Colleges and Universities.

Bowen, José A., and C. Edward Watson. 2017. *Teaching Naked Techniques: A Practical Guide to Designing Better Classes*. San Francisco: Jossey-Bass.

Brownell, Jane E., and Lynn E. Swaner. 2010. *Five High Impact Practices: Research on Learning Outcomes, Completion, and Quality*. Washington, DC: Association of American Colleges and Universities.

Daoud, Kamel. 2017. "The French Disconnection." *New York Times*, April 21, A25.

Ehrmann, Stephen C. 2017. "Improving Course Outcomes—Uses of Undergraduate Learning Assistants." Accessed April 1, 2017. http://sehramm.blogspot.com/2017/06/improving-course-outcomes-impact-of-html

Eynon, Bret, and Laura M. Gambino. 2017. *High-Impact ePortfolio Practice: A Catalyst for Student, Faculty, and Institutional Learning*. Sterling, VA: Stylus. Ebook.

Finley, Ashley, and Tia McNair. 2013. *Assessing Underserved Students' Engagement in High-Impact Practices*. Washington, DC: Association of American Colleges and Universities.

Hart Research Associates. 2015a. *National Trends in General Education Design, Learning Outcomes, and Teaching Approaches*. Washington, DC: Association of American Colleges and Universities.

Hart Research Associates. 2015b. *Falling Short? College Learning and Career Success*. Report on a Survey of Employers. Washington, DC: Association of American Colleges and Universities.

Knefelkamp, L. Lee. 1990. "Seasons of Academic Life: Honoring Our Collective Autobiography." *Liberal Education* 76(3): 4–12.

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter*. Washington, DC: Association of American Colleges and Universities.

Kuh, George D. 2017. "And Now There Are 11." Foreword to Eynon and Gambino.

Kuh, George D., Ken O'Donnell, and Carol Geary Schneider. 2017. "HIPs at Ten." *Change: The Magazine of Higher Learning* 49(5).

National Survey of Student Engagement (NSSE). 2016. *Engagement Insights: Survey Findings on the Quality of Undergraduate Education—Annual Results 2016*. Bloomington: Center for Postsecondary Research, Indiana University School of Education.

Peden, Wilson, Sally Reed, and Kathy Wolfe. 2017. *Rising to the LEAP Challenge: Case Studies of Integrative Pathways to Student Signature Work*. With a foreword by Lynn Pasquerella. Washington, DC: Association of American Colleges and Universities.

Schneider, Carol Geary. 2004. "Practicing Liberal Education: Formative Themes in the Reinvention of Liberal Learning." *Liberal Education* 90(2): 6–11.

Schneider, Carol Geary. 2015. "The LEAP Challenge: Transforming for Students, Essential for Liberal Education." *Liberal Education* 101(1/2): 6–15.

Schneider, Carol Geary. 2016. "Transforming Learning: The LEAP Challenge and the Well-Being of Students." In *Well-Being and Higher Education: A Strategy for Change and the Realization of Higher Education's Greater Purposes*, ed. Donald Harward, 281–293. Washington, DC: Bringing Theory to Practice.

State Higher Education Executive Officers Association (SHEEO). 2017. "MSC Refinement Year September 2016 through August 2017." *SHEEO*. Boulder, CO: Author. Accessed July 28, 2017. http://www.sheeo.org/msc

Carol Geary Schneider
Lumina Foundation, cgs@aacu.org

Carol Geary Schneider served as president of the Association of American Colleges and Universities (AAC&U) from 1998 to 2016 and is now a fellow with Lumina Foundation where she works on equity-minded approaches to quality learning. She coauthored Lumina Foundation's widely used Degree Qualifications Profile (DQP). While at AAC&U, she designed and led the organization's long-term initiative on Liberal Education and America's Promise (LEAP), a campus action and advocacy initiative to help college students in all academic majors reap the benefits of liberal learning. She continues to write, speak, and consult about liberal education as a necessity in a globally connected democracy and an innovation-fueled economy.

PRACTICE

Credit Where Credit Is Due: A Course-Load Banking System to Support Faculty-Mentored Student Research

Christopher S. Kim, Anna Leahy, Lisa Kendrick,
Chapman University

Abstract

Faculty participation in mentoring undergraduate research can be limited by the time demands involved and the relatively low compensation typically offered at most institutions. The system designed by Chapman University's Office of Undergraduate Research and Creative Activity (OURCA) facilitates independent research by undergraduate students who wish to receive academic credit and awards teaching credit to faculty members who mentor this research. This faculty-student research banking (FSRB) program counts student research credits toward faculty teaching loads, allowing 24 credits to be exchanged for a one-course reduced teaching load in a future academic term. The financial and structural parameters of the FSRB program and data from the first three years of its operation are provided, including guidelines developed and lessons learned, which may assist other institutions in applying and creating similar systems.

Keywords: *undergraduate research, credit, faculty workload, faculty service, mentoring*

doi: 10.18833/spur/1/1/8

Undergraduate student engagement in independent research and creative activity has been well established as one of the most high-impact, potentially transformative learning experiences available in postsecondary education, with corresponding potential benefits on student retention/graduation, faculty members' scholarly productivity, and graduates' persistence in research-related careers (Lopatto 2003; Kuh et al. 2007; Kuh 2008). However, the National Survey of Student Engagement (NSSE) indicates that only a minority of senior undergraduates self-report participation in faculty-mentored research, with percentages relatively stable at 24 ± 1.5 percent from 2013 to 2015 (NSSE 2017).

Insight into this apparent discrepancy at Chapman University, a four-year private master's university located in Southern California, can be gleaned from internal institutional surveys of its faculty members regarding their perspectives and practices on student research. These surveys largely conclude that time and energy limitations—and not, as some might anticipate, financial compensation—restrict broader engagement by faculty in the undergraduate research enterprise (Arredondo and Gordon 2010; Chapman University 2010, 2012, 2014). Viewed through the classic framework of academic tenure and promotion guidelines that emphasize scholarly output, teaching, and service, faculty are unlikely to assume the responsibility of mentoring undergraduate student researchers in addition to existing institutional expectations if the activity is not credited by the academy as teaching and is not perceived as efficiently advancing the scholarly agenda of the faculty member. The limited resource of time is a recurring theme in other studies (e.g., Zydney et al. 2002).

Chapman University has developed a system that directly addresses this issue by awarding teaching credit to faculty members who mentor undergraduate research. In operation since fall 2013, the faculty-student research banking (FSRB) program, developed by Chapman University's Office of Undergraduate Research and Creative Activity (OURCA), allows students to enroll in independent research/creative activity credits that count toward faculty teaching loads, enabling the accumulation of a set number of credits (24) to be exchanged for a one-course reduced teaching load in a future academic term. This process effectively values the mentorship of undergraduate research as a form of teaching and assigns credit accordingly.

The Rationale for Credit Banking

Although the current operation of the FSRB program primarily involves logistical and organizational oversight by a dedicated staff member within OURCA, its initial approval by the university's upper administration was dependent on detailed and sound projections of the potential financial costs to the institution. Fortunately, Chapman University has a long history (more than 10 years) of allowing students to enroll in independent study credits (which included faculty-mentored independent research and creative activities), with an existing but low compensation structure for faculty who oversaw such independent work. This data provided valuable baseline enrollment and financial information upon which the FSRB program could be developed.

A spreadsheet model to produce relevant financial calculations and projections for the FSRB program is available in Excel format to interested parties upon request to OURCA and can be easily modified to meet individual institutional needs. A basic overview of the approach is provided here. The following data is required to make all relevant calculations (see Table 1 for an example of such calculations using fictionalized sample values):

- Historical (e.g., most recent academic year) tally of independent research/study credits undertaken by students
- Annual full-time undergraduate tuition rate
- Average full-time undergraduate tuition discount rate, representing all financial aid, scholarships, and fellowships
- Average academic credits/year taken by full-time undergraduates
- Prior faculty compensation for mentoring student research (if applicable)
- Adjunct/part-time faculty compensation rate
- Proposed FSRB conversion rate of research credits to teaching credits

With this information in hand, the model can be used to calculate the following:

- Net costs/revenues generated under the prior compensation system
- Predicted net costs/revenues associated with varying conversion rates (e.g., 25 percent, 50 percent, 100 percent) from the prior compensation system to the FSRB program

Model calculations by necessity make a number of assumptions, including (1) faculty course load reductions will be covered entirely by adjunct faculty, (2) benefits are not a part of the calculation for adjunct compensation costs, and (3) students participating in research in general meet the average student discount rate.

TABLE 1. An Example of Financial Calculations and Cost Projections for the Faculty-Student Research Banking Program (FSRB)

Institutional data	
Student research credits/year (from historical data)	1200
Annual tuition	$40,000
Discount rate	40%
Average credits/student/year	32
Prior faculty compensation/credit for mentoring student research	$100
Adjunct faculty compensation/teaching credit	$1,500
Revenues generated under the prior system	
Annual total revenues generated	$900,000
Annual faculty compensation cost	$120,000
Annual net revenues generated	*$780,000*
Revenues generated under the FSRB program	
Ratio of research credits to teaching credits	8:1
Total teaching credits accrued/year	150
Total number of 3-credit classes accrued/year	50
Maximum annual adjunct compensation cost	$225,000
Minimum annual net revenues generated	$675,000
Revenue projections for the FSRB program	
Net revenue under current system	$780,000
Net revenue given 25 percent transfer to FSRB	$753,750
Net revenue given 50 percent transfer to FSRB	$727,500
Net revenue given 100 percent transfer to FSRB	$675,000
Cost projections for the FSRB program	
Cost @ 25 percent credit transfer to FSRB	$26,250
Cost @ 50 percent credit transfer to FSRB	$52,500
Cost @ 100 percent credit transfer to FSRB	$105,000

Note: Figures for illustration purposes only (not actual)

Model projections conducted for Chapman University indicate that the additional cost to the university to initiate the FSRB program, based on historical data, would not exceed approximately $140,000 per year, assuming a highly conservative 100-percent conversion rate of historical independent study/research credits to the FSRB program. This calculation was sufficient grounds for the university's chancellor and chief operating officer to approve the launch of the program on a trial basis starting fall 2013, with a planned review after its first 1–2 years of operation to determine whether any adjustments were needed.

The Faculty-Student Research Banking Program (FSRB)

Definitions

For the purposes of academic credit, Chapman University's undergraduate catalog definition of student-faculty research and creative activity resembles that of the Council on Undergraduate Research: "independent, faculty-mentored scholarly research/creative activity in their discipline which develops fundamentally novel knowledge, content, and/or data" (Chapman University 2015). This description emphasizes the following requirements:

1. The student will work both independently and under the mentorship of a faculty member.
2. The final outcome of the work is to be novel—original or innovative—within the discipline in which the research or creative activity is conducted.

The emphasis on these two aspects distinguishes this credit option from regular coursework for major and general education requirements as well as from other types of independent study such as reading courses.

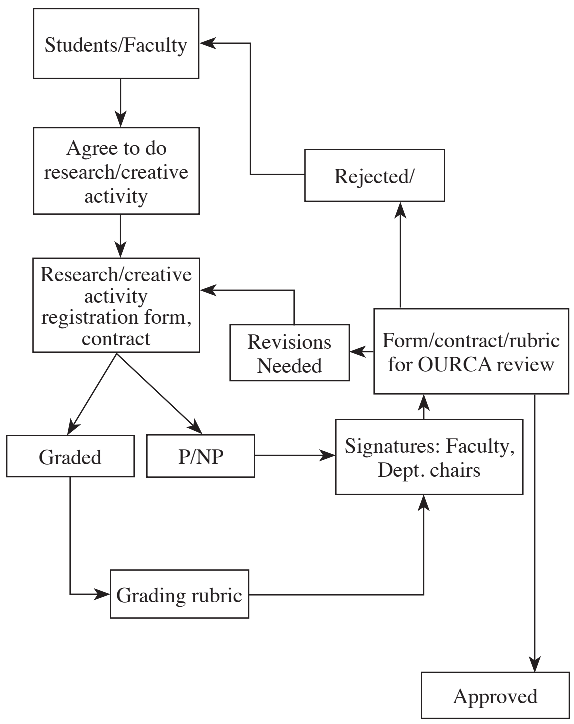
In practice, participation in independent research and creative activity for academic credit can be initiated by either the student or the faculty mentor. For example, a research-based, scholarly, or creative project could be one originated by the student based on his or her interests, expertise, and program of study; the student would then seek a faculty mentor to supervise work on this project as part of the course. Alternatively and more commonly, a project could originate with a faculty mentor as part of a larger area of study under exploration by the professor; the faculty member then would seek/recruit a student to mentor. In some fields or for some projects, research or creative activity is conducted in a team format; in such cases, each student is responsible for distinct tasks and makes an individual contribution to a larger project to fulfill the requirements for the research credits.

Structural Components

Figure 1 shows a workflow model that demonstrates the development, submittal, and approval process for student-faculty collaborative research or creative activity. Proposals are encouraged during regular course enrollment periods in the prior academic term (e.g., midway through fall semester for participation in the spring semester), and the deadline for proposals is the university add/drop deadline, which in a regular semester occurs at the end of the second week of classes; this represents a minimum 12-week window for enrollment in independent research credits. Proposals are usually reviewed by OURCA within a few days of submission. Sometimes, more information is requested from the student; the most common omission is the grading rubric required for research credits in which the student has enrolled for a letter grade (versus the "pass" or "no pass" option). The proposal serves as an agreement among the student, faculty mentor, and the university, and OURCA review works to ensure compliance with the program's guidelines and a match between the proposal and the student's work tracked through the semester. The registrar's office is notified of approved proposals and establishes each course section.

Students may enroll in 1–3 independent research or creative activity credits per academic term in nearly all academic disciplines under the 291 (lower class), 491 (upper class), and 682 (graduate) course number designations, allowing for intermediate and advanced work at the undergraduate level as well as graduate-level work. Enrollment can be repeated for credit so it can be used

FIGURE 1. Flowchart Showing the Approval and Enrollment Process in Independent Student-Faculty Research/Creative Activity Credits Under the Faculty-Student Research Banking Program (FSRB)



for an independent project that spans multiple semesters. These designations were added to the university catalogs across departments at the same time, so that the credit option is available to students regardless of major or area of interest. For example, a BFA student in creative writing could enroll in ENG 491 to draft a novel—a creative project that is not supported directly by the curriculum—whereas a BS student in chemistry could enroll in CHEM 491 to conduct innovative experimental research as part of a larger research team.

The main exception to the across-the-board inclusion of the 291/491/682 designations in all academic units is Chapman University's business school, which chose to include this option with the BUS designation and not in its various major designations for accounting, finance, marketing, and so forth. This exception suggests that some academic programs have different uses in the curriculum for this course option and banking system than others. In addition, some department chairs expressed concerns about course coverage and class scheduling as faculty began to redeem credits for reduced course loads, which in some cases prompted chairs to develop additional departmental guidelines/restrictions on the ways in which their faculty participate in the FSRB program. Although the opportunity to register for independent research/creative activity credits ideally should be available widely across and within disciplines, it remains a challenge to ensure consistent participation in the FSRB program by all academic units. OURCA maintains ongoing conversations with chairs to address their concerns, assure them of their discretion to approve credit enrollments and teaching reductions, and expand the reach of the FSRB program where feasible. The reasons behind varied levels of participation from unit to unit are often multiple and institutionally based, and a given institution will likely need to adapt and implement its version of the FSRB program accordingly.

In practice, the 491 courses are used for research far more frequently than the 291 courses, with the former representing 90 percent of all student participants since the program's inception. Some faculty have suggested that upper-class undergraduates have the most expertise to conduct independent research or creative activity and produce novel knowledge. The significantly lower registration numbers at the 291 level may reflect the institutional culture and an opportunity in the future to build ongoing or deeper research experiences for undergraduates across their college years.

Notably, restrictions were created to ensure that independent research/creative activity credits would complement rather than compete with the existing curriculum and to avoid exploitation of the FSRB program to achieve internal departmental goals. This option, therefore, may not replace existing capstone courses or fill required curricular gaps in a major or degree program. Students cannot earn independent research/creative activity credit for classroom-based assignments. In other words, students and faculty cannot "double-dip" by using the same work for a classroom-based course as well as independent research. Another logical restriction is that a student cannot be paid as a research assistant for the same work—the same hours—that is counted toward research credits. Students paid as lab assistants for data collection, for instance, cannot enroll in academic credit for that same research task.

So as not to put undue burden on the banking system and to maintain a reasonable faculty workload, no major can require participation of all students in independent research/creative activity. The experience is designed to complement rather than substitute for degree requirements, and administrators expressed reasonable demands that faculty not bank credits that are required of students to complete a particular major. Independent research/creative activity credits have been allowed, however, as one among several options that include a summer research fellowship or a research internship for majors that already had in place a restricted research requirement for the capstone. It is likely that each academic institution will need to adjust FSRB policies according to its curricula and resources.

All regular university academic calendar deadlines—add/drop, change in number of credits, change in grading option, withdrawal, and so forth—apply to independent research/creative activity credits. Because of the extra registration paperwork required by OURCA and the registrar, students are encouraged to complete their registration forms during the regular registration period in the prior academic term; however, as previously mentioned, students may technically register for independent research/creative activity credits (as they can with any other course) up until the second week of classes.

The default and recommended grading option for independent research/creative activity credits is pass/no pass. However, the student, with approval of the faculty mentor, can also opt for a letter grade; in this case, a grading rubric must be submitted and approved by OURCA as part of the registration paperwork.

Student Requirements

Consistent with university-wide policies for all coursework, a student enrolled in independent research/creative activity credits must accomplish the following:

1. Meet with the faculty mentor for a minimum of five contact hours cumulatively over the course of the academic term.
2. Complete an average of three hours of research/creative activity per week per credit for the duration of the academic term.

Three credits of independent research/creative activity, then, requires an average of 9 hours commitment per week or 126 hours over the standard 15-week semester (excepting the one-week Thanksgiving break in the fall and spring break in the spring semester). To document this work, a student completes a weekly progress report within the Blackboard course management system that records the tasks and hours committed for each day of the prior week. The faculty mentor checks these reports on a regular basis, then transfers approved hour totals for each week to the course Grade Center in Blackboard. Although some faculty have bristled at this requirement for documentation, the university benefits from accurate, timely tracking to ensure compliance with credit requirements. Credit management is greatly aided by the fact that all course registrations (including independent research/creative activity credits) approved by the registrar automatically initiate the creation of a distinct Blackboard course website into which OURCA can transfer the weekly progress report and Grade Center settings. Failure to complete the required hours results in the recommendation of a NP or F grade, although circumstances allow for faculty discretion, including the possibility of assigning an "incomplete" grade as governed by the catalog policy on grading.

In addition to documented progress through the weekly progress reports, a student is required to upload an "end-of-semester deliverable," a culminating documentation of research/creative activity conducted during that academic term. OURCA requires that the deliverable be uploaded and all hours be transferred to the Grade Center in Blackboard by the end of the last week of classes to allow OURCA to verify the completion of credit requirements during final exam week. Often, if the student presents the research or creative activity as a poster at the university's Student Research Day (also coordinated by OURCA), the poster is submitted by the student as the end-of-semester deliverable. The faculty mentor, however, determines the form taken by the deliverable, as appropriate to the discipline in which the work is done. For example, a creative writing student might upload a draft of the novel she wrote, whereas a dance student might upload a video of a performance he choreographed.

Because OURCA initiated and developed the FSRB program, it oversees the logistics and tracking for all registered credits. Although the program continues to serve mainly undergraduates, OURCA also tracks the graduate-level credits instead of splitting the process and documentation with the Office of Graduate Education. All OURCA efforts in this program are closely coordinated with the registrar's office (for student credit) and the provost's office (for faculty-banked credit) with the assistance of the Office of Academic Technology. The communication and cooperation among these campus units is important for establishing and maintaining a successful, smoothly run program.

Faculty Requirements

To participate in the FSRB program, a faculty mentor must be on full-time status and not taking a sabbatical or another form of academic/medical leave. Although it is not a stated requirement, the program assumes that faculty will have expertise in the general area of research or creative activity in which they mentor.

When mentoring a student for independent research/creative activity credits, a faculty mentor must complete the following tasks:

- Review the student's hours as reported in the weekly progress reports and transfer the approved number of hours to the Blackboard Grade Center on a regular (ideally weekly) basis.
- Hold a minimum of five individual (not group) contact hours with the student.
- Review the end-of-semester deliverable prior to submission.
- Submit the final grade as part of the regular grade submission process.

Failure to complete these tasks will result in the faculty member forfeiting, instead of banking, the research credits.

Faculty Usage of Banked Credits

Once a faculty member has accrued the minimum number of banked credits (24), he or she is eligible to request a course load reduction in an upcoming semester. The process was designed with considerable lead time (i.e., the request must be placed in the fall semester for the *following* academic year) to accommodate both the faculty member and the department chair in arranging a replacement instructor for the course. The basic steps and associated deadlines for requesting and verifying course load reduction are as follows:

- Nov. 1: The faculty member completes and submits the FSRB Course Load Reduction Request Form via email to OURCA and the department chair to request course load reduction for a specific term in the forthcoming academic year.
- Nov. 15: OURCA verifies that the faculty member has accrued sufficient credits and forwards the request form with verification to the department chair (copying the faculty member and the vice provost of academic administration).
- Dec. 15: The department chair approves the course load reduction request, forwards it to the vice provost (copying the faculty member and OURCA), and makes an appropriate adjustment in scheduling for the forthcoming academic year, *or*

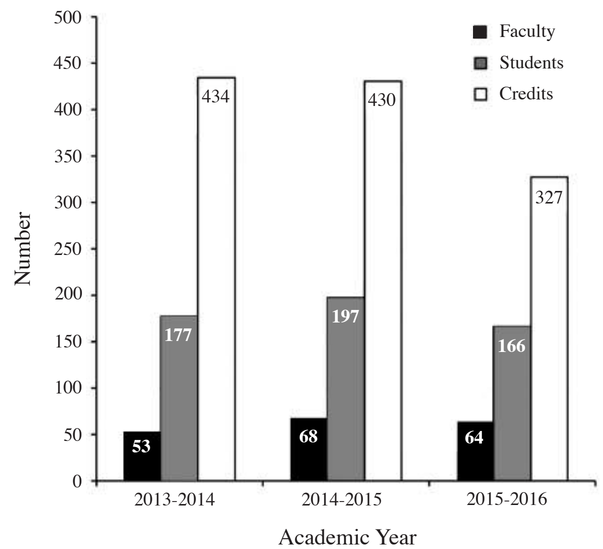
  The department chair declines the course load request, indicates an alternate semester when the course load reduction will be accommodated (ideally within the subsequent academic year), and forwards the request to the vice provost (copying the faculty member and OURCA).

- Jan. 15: The vice provost approves plans for the course load reduction and sends the form back to the faculty member for final signature indicating confirmation of plans (copying the department chair and OURCA).
- Jan. 30: The faculty member forwards the completed form with all required signatures to OURCA for final recordkeeping.
- Academic term: OURCA subtracts the appropriate number of credits from the faculty member's account at the start of the term in which the course load reduction is provided and updates the current balance for the faculty member.

Participation Rates and Analysis: 2013–2016

Participation rates in the FSRB program were relatively strong upon its launch in academic year (AY) 2013–2014 (see Figure 2), with a substantial increase in participation during the spring semester (not shown) as awareness increased among faculty and students. On a credit comparison basis, the degree of participation in the program's first year (434 credits) translated to a 30 percent conversion rate from the historical compensation program (approximately 1400 credits in the prior AY), corresponding to $42,000 in associated costs based on model projections. However, these costs were not actually realized during that academic year, as most faculty had not yet accrued the threshold number of 24 credits to allow such a request after only one year; accordingly, no course load reductions were actually requested. This level of participation persisted in AY 2014–2015, with nearly identical rates of credits accrued over the course of the year and moderate increases in the numbers of individual faculty and students participating (see Figure 2).

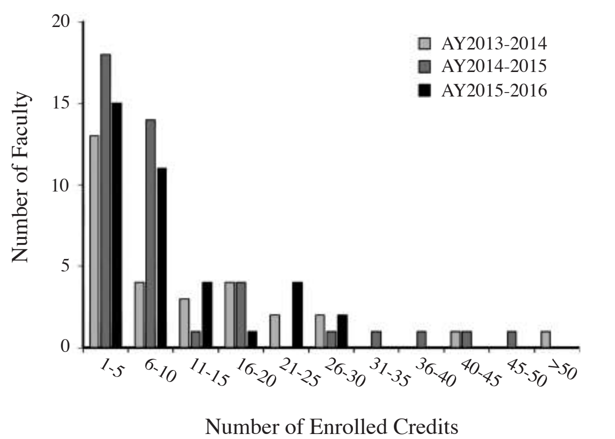
FIGURE 2. Numbers of Faculty Participants, Student Participants, and Credits Accrued in the Faculty-Student Research Banking Program (FSRB) Annually from 2013 to 2016



The FSRB program was initially launched without restrictions on faculty participation to observe how faculty would engage in the program and how many students/credits they would mentor in the absence of any restrictions. After the first two years of the FSRB program's operations, analysis showed that the number of banked credits per faculty member averaged 7.1 per year, with a median of 3. However, a few outlying faculty members were able to accrue high numbers of credits in great excess of this average (as high as 66 credits in one year in one case). This is apparent in a histogram of annual faculty credit accruals under the FSRB program from 2013 to 2016 (see Figure 3). To mitigate excessive levels of participation by these few individuals that would have affected the long-term financial viability of the program, limitations on accrual and usage rate were implemented effective in AY 2015–2016. Faculty can now accrue a maximum of 12 credits per semester and 6 credits per summer or interterm (an accelerated four-week academic term in January), and a faculty member can reduce his or her teaching load by a maximum of two courses per academic year. These limitations would not have affected the vast majority (more than 95 percent) of faculty participants if instituted in the prior two years and effectively served the purpose of curtailing only faculty who had been accruing credits at a much higher rate, as evidenced in the clear histogram shift for AY 2015–2016 (see Figure 3).

In AY 2015–2016, this program experienced variable declines in participation by faculty (-6 percent), students (-16 percent), and credits (-24 percent) (see Figure 2). These declines can be attributed, in part, to additional restrictions that some department chairs chose to put into place out of concerns that the departments would be unable to offer all required courses because of the distribution of expertise among existing faculty. However, much

FIGURE 3. Histogram of Annual Faculty Banked Credit Accruals Under the Faculty-Student Research Banking Program (FSRB) from 2013 to 2016 (Faculty with More than 24 Credits Are Eligible for Course Load Reduction)



of this decline can likely be attributed to the removal of the high credit accrual of a few faculty members observed in the first two years through the FSRB policy revisions, as evidenced by a greater percentage reduction in credits than in faculty or student participants. Notably, although the average banked credits per faculty member declined from 7.1 in the first two years to 5.1 in the most recent year, the median number of banked credits remained stable year-over-year at 3. Thus, the most current data may well represent the baseline degree of FSRB participation upon which OURCA can build in the future through additional programming and communication.

Institution-specific NSSE data from 2013 and 2015 (Chapman administers the NSSE in an alternate-year cycle) show that the percentages of Chapman seniors responding affirmatively to the category "Work with a faculty member on a research project" (42 percent and 36 percent, respectively) significantly exceeded the 20 percent national average for master's-level colleges and universities (larger programs) over the same time frame (NSSE). However, since this NSSE category could also be interpreted as including class-based research projects and because the NSSE gathers data from only graduating seniors and first-year students, the survey cannot necessarily be considered an accurate institution-wide measurement of participation and trends in independent student research.

Conclusions

The FSRB program is a viable system by which faculty and students can collaborate on independent research and creative activity while receiving teaching and academic credit, respectively, for doing so. Due to the relatively short time period the program has existed, the number of course load reductions has been minimal (1 course in AY 2014–2015, 3 courses in AY 2015–2016, and 1.5 courses in AY 2016–2017), although requests are expected to increase in subsequent years as more faculty accrue sufficient credits to merit course-load reduction.

Ongoing and future improvements include (1) increasing the transparency of accrued credits to both department chairs, other administrators, and the faculty members themselves each semester in order to better manage curricular offerings and schedules; (2) updating and projecting the financial costs of the FSRB program every semester to account for course-load reductions and the associated adjunct hiring costs; and (3) using demographic data from the first three years of participation in FSRB to identify academic programs that have a lower participation rate relative to others and determine strategies to increase their representation/activity in those programs. The success of the FSRB program in academically institutionalizing and properly rewarding the activity of faculty-student research collaborations is one that may serve as a useful model for other institutions to follow.

References

Arredondo, Marisol, and Ann Gordon. 2010. "Attitudes of Chapman Full-Time Faculty toward Undergraduate Research." Internal report, Institutional Research Office (CIRO). Orange, CA: Chapman University.

Chapman University. 2010, 2012, 2014. "Faculty Assessment of Undergraduate Research at Chapman University." Faculty Survey, Institutional Research Office (CIRO). Orange, CA: Author.

Chapman University. 2015. *2015–2016 Undergraduate Catalog*. Orange, CA: Author. Accessed May 1, 2016. http://www.chapman.edu/catalog/oc/current/ug/

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter*. Washington, DC: American Association for Colleges and Universities.

Kuh, George D., Jillian Kinzie, Jennifer A. Buckley, Brian K. Bridges, and John C. Hyek. 2007. "Piecing Together the Student Success Puzzle: Research, Propositions, and Recommendations." *ASHE Higher Education Report* 32(5): 1–182.

Lopatto, David. 2003. "The Essential Features of Undergraduate Research." *CUR Quarterly* 24(1): 139–142.

NSSE (National Survey of Student Engagement). 2017. "Past Summary Tables." Bloomington: Center for Postsecondary Research, Indiana University. Accessed May 1, 2016. http://nsse.indiana.edu/html/past_summary_tables.cfm

Zydney, Andrew L., Joan S. Bennett, Abdus Shahid, and Karen W. Bauer. 2002. "Faculty Perspectives Regarding the Undergraduate Research Experience in Science and Engineering." *Journal of Engineering Education* 91: 291–297. doi: 10.1002/j.2168-9830.2002.tb00706.x

Christopher S. Kim
Chapman University, cskim@chapman.edu

Christopher Kim is professor of earth and environmental sciences and associate dean of academic programs in the Schmid College of Science and Technology at Chapman University. As an environmental geochemist who investigates metal contamination in natural settings, specifically focusing on abandoned mine lands in California, he has raised more than $2 million in external funding to conduct environmental research with undergraduates at Chapman. Kim has served as a councilor in the Geosciences Division of the Council on Undergraduate Research, co-chaired the 2016 CUR Biennial Conference, and served as director of Chapman's Office of Undergraduate Research and Creative Activity from 2011 to 2015.

Anna Leahy is professor of English in the Wilkinson College of Arts, Humanities, and Social Sciences at Chapman University. She has served as the director of the Office of Undergraduate Research and Creative Activity since 2015 and also directs Tabula Poetica, *a poetry project at Chapman University that hosts an annual reading series and houses the journal* TAB. *Leahy publishes widely in creative writing pedagogy and is currently researching how different fields define creativity.*

Lisa Kendrick is the administrative coordinator of the Office of Undergraduate Research and Creative Activity at Chapman University. A Chapman alumna, she maintains primary administrative oversight over the Faculty Student Research Banking program.

PRACTICE

Building a Business Model for Funding Undergraduate Research

Joseph J. Shields, Julio C. Rivera, *Carthage College*
Joseph M. Wall, *Marquette University*

Abstract

This article discusses a set of projects that build on the following concepts: the private sector has the ability to fund undergraduate research projects, the private sector is hungry for projects that focus on the scholarship of application and engagement, and students can be empowered beyond a particular research project in this funding model. Through a student-run organization, several departments came together for consulting research projects. Although formal research projects are not the sole activity of the organization, many have been accomplished and presented at academic meetings, highlighting a "theory-to-practice" approach. Most of the client work scaffolds students' learning of research methods, support students' ability to participate in other research experiences, and provide real examples of completed projects that assist students in applying to graduate school or seeking work in the professional world.

Keywords: *funding, scaffolding, student organization, consulting*

doi: 10.18833/spur/1/1/4

Externally funded undergraduate research projects involve seeking and receiving grant money from government and foundations. This article discusses projects that emerged from the following ideas:

- the private sector has the ability to fund undergraduate research projects,
- the private sector is hungry for projects that focus on the scholarship of application and engagement, and
- students can be empowered beyond a specific research project in this funding model.

The article will also discuss the evolution of this initiative, which began as a departmentally focused practice and eventually incorporated a multidisciplinary and transdisciplinary approach to projects.

Historical Backdrop

Carthage College has a long history of research projects in the community of Kenosha-Racine, Wisconsin. Many faculty have worked on projects within the scholarship of application and engagement with large corporations, small companies, government agencies, and nonprofit groups. The departments known for this work have included business, chemistry, entrepreneurial studies, geography, physics, and sociology. Projects have included monitoring water quality, conducting geo-demographic research, and working with small companies. Most of these projects have been "as needed" and focused on an individual faculty member or department. The development of a student-run consulting organization began to shift projects from those with an individual focus to those with a team focus.

Academic Grounding

The push for business schools to change and adapt to the needs of organizations, ensuring graduates develop the skills required for organizational success, has been a recent emphasis and concern in research (Bennis and O'Toole 2005; Ghoshal 2005; Hawawini 2005; Mintzberg 2004). The increased use of teams to work (especially in action learning) in corporate settings has resulted in the development of action learning programs as part of graduate and undergraduate programs in business schools (Raelin 2006). Action learning is defined as "a method to generate learning from human interaction occurring as learners engage together in real time work problems"

(Raelin 2006, 152). In operation, action learning involves students working together with a client on real-world problems so the students can use what they have learned (disciplinary knowledge or theories) to complete projects given to them. Thus, action learning can be closer to authentic pedagogical methods within management education (Mintzberg 2004).

Similarly, service learning has long been a critical component of high-impact educational practice (Kuh 2008). Although the ability to apply classroom knowledge in the outside world has always been a central tenet, recent research (Levesque-Bristol, Knapp, and Fisher 2010) suggests that motivation, civic skills, problem solving, and an appreciation of diversity accompany the process. Further civic (Prentice 2007) and classroom engagement can increase as a result of the experience. Thus, an organization built on teams that service internal needs, nonprofits, governmental units, and for-profit companies can leverage a novel blend of active and service learning to increase the holistic outcomes for students.

The Establishment of Velocity Consulting

In September 2010, Joseph Wall decided to create a student-run accounting/finance consulting group, and Joseph J. Shields was starting a student-run marketing agency. When the two faculty members learned of their independent endeavors during a department meeting, they discovered the overall objectives for both organizations were the same:

1. Create an environment where students could apply what they learned in the classroom to "real-world" projects and, in the process, prepare students for their first job upon graduation or graduate school.
2. Create an organization that is financially self-sustaining.
3. Run the organization as a business, not as a traditional student organization. Meeting deadlines, promoting accountability, and developing high-quality work were the priorities of the organization.

Rather than establishing two independent groups that shared the same objectives, creating just one organization was deemed to be a more effective move. The student-run, full-service consulting service and active learning organization was named Velocity Consulting.

The provost's office approved both the idea and the organization with one additional caveat. Velocity would be specifically linked with the undergraduate research programs at the college. Many of the potential projects for clients could form authentic student research and scholarship under the Boyer model of scholarship (Boyer et al. 2015). Projects that might not reach that standard would involve elements of complexity and skill building for students to scaffold research skills (Chamely-Wiik et al. 2014). Funds from the provost's office and the undergraduate research program were not allocated to support the project, and the project has maintained self-sustainability from the outset.

During the early planning process for Velocity, it became clear that Velocity must be built on attracting students whose sole reason in joining the organization was to learn and gain valuable experience that could be leveraged for students' graduate school applications or first employment opportunity. Although nonprofit and internal service projects have not resulted in credits thus far, the business community has been receptive to the experience, as noted in Table 1. However, students have received compensation as well as internship credit for in-depth summer projects, due to the extensive one-on-one research performed by a faculty member working with one student. Client fees received are reinvested in the students and are used for food and beverages at the weekly staff meetings, business cards, embroidered shirts for the students, supplies, and professional development programs for the students in Velocity. Faculty are not compensated for their work, although advising a student organization counts as service. The annual operating cost for Velocity Consulting in 2014–15 was around $5,000. This included pizza and soda for every weekly staff meeting, printing costs for client project reports, Velocity Consulting embroidered shirts, and office supplies. This model continues to evolve and change so that best ethical practices are ensured and that students continue to learn and receive great value from the experience.

The early vision for Velocity was that it would work for clients across the economic spectrum—such as large, well-known companies; small businesses; government entities; and small nonprofit groups—and would charge fees on a sliding scale appropriate for the client along with some pro bono work. This model has been successful at funding all aspects of Velocity's operation as well as creating a healthy surplus that could sustain current operations for multiple years.

To achieve the benefits of active and service learning, as mentioned earlier, Velocity takes on a variety of clients. Clients may be categorized as pay for services or as pro bono. The associated projects may involve substantial applied research or focus on service and thus have little applied research. This novel blend of research, practice, and service develops the whole of the student and aligns with the overall mission of the college.

By October 2010, Velocity was operational and included a core of five students who completed the essential elements for the new business. By February 2011, the mission, vision, organizational structure, job descriptions, branding identity, and marketing materials had been established and approved by the college. A board of

TABLE 1. Functional Areas of Operation

Student expertise leveraged by Velocity projects	Typical deliverables	Typical number involved	Achieved full-time employment or graduate school placement partially or directly due to involvement
Accounting Systems (Accounting Majors)	Accounting reconstruction, accounting process design, and financial statement construction	5	100%
Financial Analysis (Finance)	Ratio analysis, risk/return sensitivity, and financial statement construction	12	100%
Economic Impact Studies (Economics)	Regressions, economic statistics, and forecasting	4	100%
Product Testing (Science)	Scientific validation, testing, and recommendations	6	100%
Marketing Research (Marketing and Math)	In-person data collection, analysis, and summaries	10	100%
Geographic Information Science and Geospatial Analysis (GIS)	Geospatial analysis and recommendations	3	100%
Press Releases (Public Relations and Communications)	Public press releases, website communications, and email	2	100%
Business Plans (Management)	Integrated business plans	6	100%
Marketing Plans (Marketing)	Strategic articulation maps and actionable recommendations	12	100%
Product Brochures (Graphic Design and Art)	Flyers, business cards, and graphical website design	6	100%
Web Design (Computer Science Majors)	Functional website design, maintenance, and updates	3	100%
Annual Reports (Accounting, Finance, and Art)	Full annual financial reports with qualitative text and financial statements	8	100%
Speech Writing (English and Public Relations)	Public and televised presentation remarks	3	100%
Training Materials (English and Graphic Design)	Product training manuals	4	100%
Social Media (Marketing and Public Relations)	Wikipedia entries, Twitter, Facebook, and website	3	100%
Event Marketing (Management)	Project management design and implementation	10	100%
Curriculum Design (Education)	Curriculum theory, suitability studies, and suggested curricula	3	100%

directors was also created and included Wall and Shields plus two local business executives.

The founding students developed the following mission/vision for Velocity Consulting:

> *Mission Statement:*
> Carthage students gain real life business experience and build an incredible portfolio, by working and running a full-service consulting agency for businesses and nonprofits.
>
> *Vision Statement:*
> To become the go-to resource for Kenosha/Racine area businesses and nonprofits while becoming THE organization that Carthage will want to boast about.

Early Progress

Velocity's first client was secured in March 2011. Carthage College asked Velocity to promote the campus Celebration of Scholars event and to assist in its management. This pilot project was a huge success. More than 100 students presented their work with submissions and attendance greater than double the initial projections. The event proved that a student run, full-service agency model could work.

Velocity's first paying client (May 2011) was Kenosha County Parks and Recreation Department, which wanted an economic analysis and marketing plan to address its two failing golf courses. This considerable project involved 14 students from different departments who conducted 402 in-person surveys with golfers at the courses, geo-demographic (GIS) and economic research, a competitive pricing analysis, an economic impact analysis, and an industry analysis. Figure 1 depicts the progression of the project.

The final report submitted by the student team to the Kenosha County Board in November 2011 included 107 pages of information and research findings. After the students presented their plan, one senior board member commented:

> The County Board has had many consultants make presentations to us on various issues, but this Velocity group did the best job. I thought theirs was the most professional, most direct, most to the point, and head and shoulders above the professional groups I've seen.

The amount of research required for the Kenosha Parks project was considerable. After the project was completed, the faculty advisers had a "Eureka Moment" and recognized that Velocity Consulting could be the perfect model for self-sustaining undergraduate research, since many of the clients paid for this work.

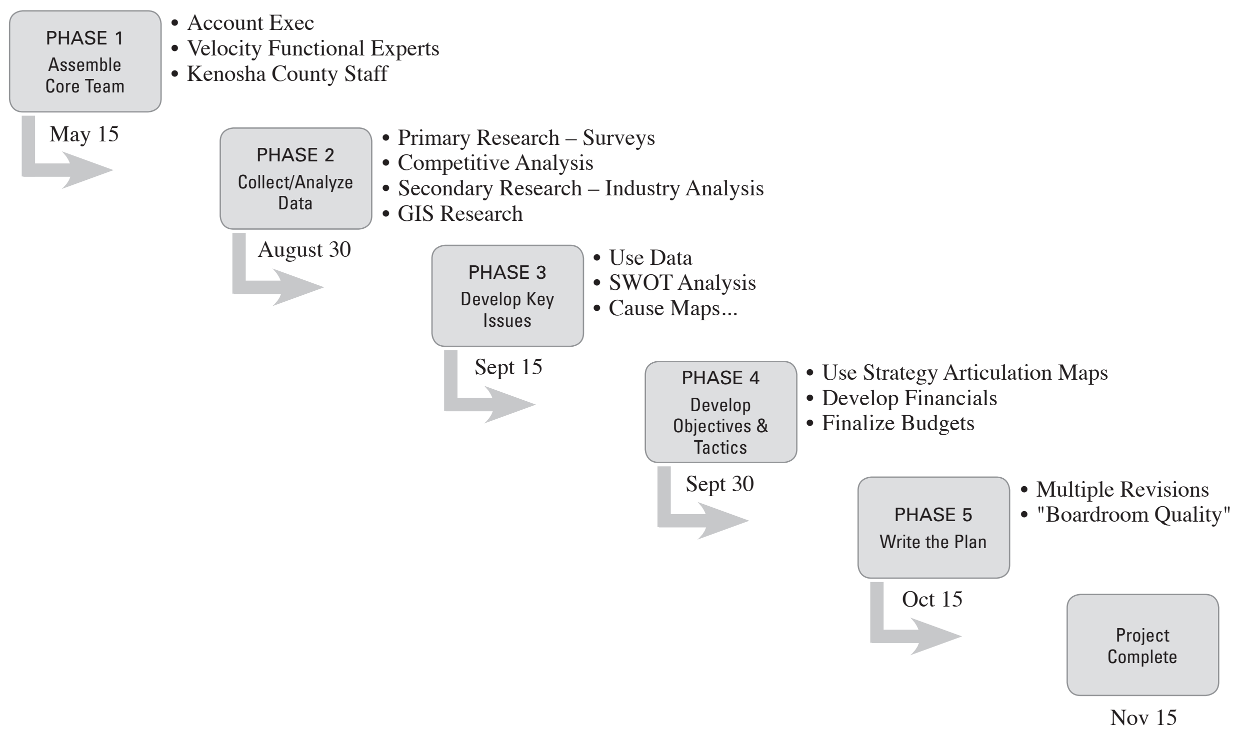
The second "Eureka Moment" came in 2012 when a client required scientific research concerning water purification. At that time, there were no students in Velocity who had the appropriate scientific skills to complete the project, so the Velocity students reached out to chemistry and biology majors to join the project. This step clearly demonstrated that the Velocity model could also serve as a robust platform for interdisciplinary research.

During the past four years, Velocity completed dozens of projects that combined research, scholarship, and creative activities. Some of the projects developed into deeper research projects for students and faculty later on. Some of the areas of research and creative expertise offered by Velocity to clients illustrate the interdisciplinary and trans-disciplinary nature of the model, capitalizing on the range of talents of students across the college (see Table 1).

Any student regardless of class year or major can join Velocity Consulting. Interested students are invited to attend a weekly staff meeting and listen to the project updates. If they wish to join one of the projects, they submit their resume to the director of human resources for Velocity Consulting. Currently the student ratio includes approximately 10 percent freshmen, 20 percent sophomores, 40 percent juniors, and 30 percent seniors. About 60 percent of students are business majors, and 40 percent are from majors other than business. The wide disciplinary range of student participants has created a strong ethic of peer mentoring among the members.

Interdisciplinary research often is conducted within the "top-down" paradigm in which two or more faculty members collaborate on a project and then find students to staff the project. The Velocity Consulting approach

FIGURE 1. Timeline and Process for the Initial Major Project



flips this model, as the Velocity students reach out to other students to staff their project and find people with the appropriate skills. This process often requires involvement from multiple disciplines to complete the client's project. Students will also recruit appropriate faculty members to provide guidance.

Building opportunities for students to perform meaningful research in the community can be difficult. However, through this organization, the students have become a self-sustaining and self-regulating group. Finding clients is not difficult. Initially, the Velocity organization included three salespeople to secure new clients. However, after the first year, it became apparent that there were better and easier ways to find and connect with new clients (such as through the chamber of commerce, alumni of the school, local business organizations, and word of mouth). The next year, Velocity had nine active clients/projects that stretched resources to a point where the organization could not accept new clients for the remainder of the year.

Organizational Operation and Adjustments

Faculty members involved with Velocity initially screen all new potential clients to understand the scope of the particular project and assess it using the following criteria developed by the students:

- Probability of success
- Political implication
- Total resources required
- Internal talents
- Client reputation
- Length of project
- Deliverables/showcase
- Availability of data/information
- Payment
- Measurability
- Involvement of client
- Breath and depth

Based on these criteria, the faculty members decide whether to recommend moving forward with the project. If their recommendation is positive, the client is invited to a weekly staff meeting to present details of the project. After the presentation, the client leaves the room, and the students debate the merits of the project and vote whether to take on the project. There have been a few projects rejected by the students, mostly due to a lack of interest in the project.

Account executives (AEs) serve in the most important role in the organization. As project managers, they are responsible for the successful completion of their project. For this reason, the board of directors reserves the right to select the AEs for each project/client. Account executives are directly responsible for a range of duties.

Upon the approval of a project, the AE will meet with the client to define the scope of the work and complete a Project Charter document that defines the project objectives, assumptions, scope, milestones, deliverable, roles/responsibilities, budget, and resources. The supervising faculty member assigned to the project, the client, and the AE all sign this document. The AE will staff the project with input from the director of human resources. Sometimes the AE may have to recruit students to join Velocity Consulting, because the current Velocity students do not have the particular required skills for the project. The AE is the "point person" with the client and is the only person who meets with the client. The AE schedules regular meetings with the team, assigns tasks, and manages deadlines. At the conclusion of a project, the AE determines which students will be recognized for their work on the acknowledgments page of the final client report. Only these students will receive a copy of the report that they can include in their portfolio for job interviews.

Initially Velocity Consulting had a very complex organizational structure that included co-chief executive officers, six vice-presidents, and several directors. This situation caused too many students to focus on attaining preferred job titles rather than on completing projects. The organizational structure was simplified after the first year, establishing one CEO and two directors (communications and human resources). As a result, the focus is now on account executives (project managers) and the completion of client projects, not on job titles. Figure 2 provides a before-and-after snapshot of the impact of the reorganization on the organizational structure, and Figure 3 shows the students involved in Velocity Consulting.

Allocation of the Money

Proper dispersal of incoming funds remains a core issue for Velocity and its faculty advisers. As previously mentioned, the organization provides food, company shirts, and business cards for the students. However, a surplus develops from time to time that may fund additional services for student participants. Some of the ideas under consideration are the following:

- Creating a program of professional development for the Velocity staff
- Supporting undergraduate research in other areas of the college
- Funding philanthropic projects in the community

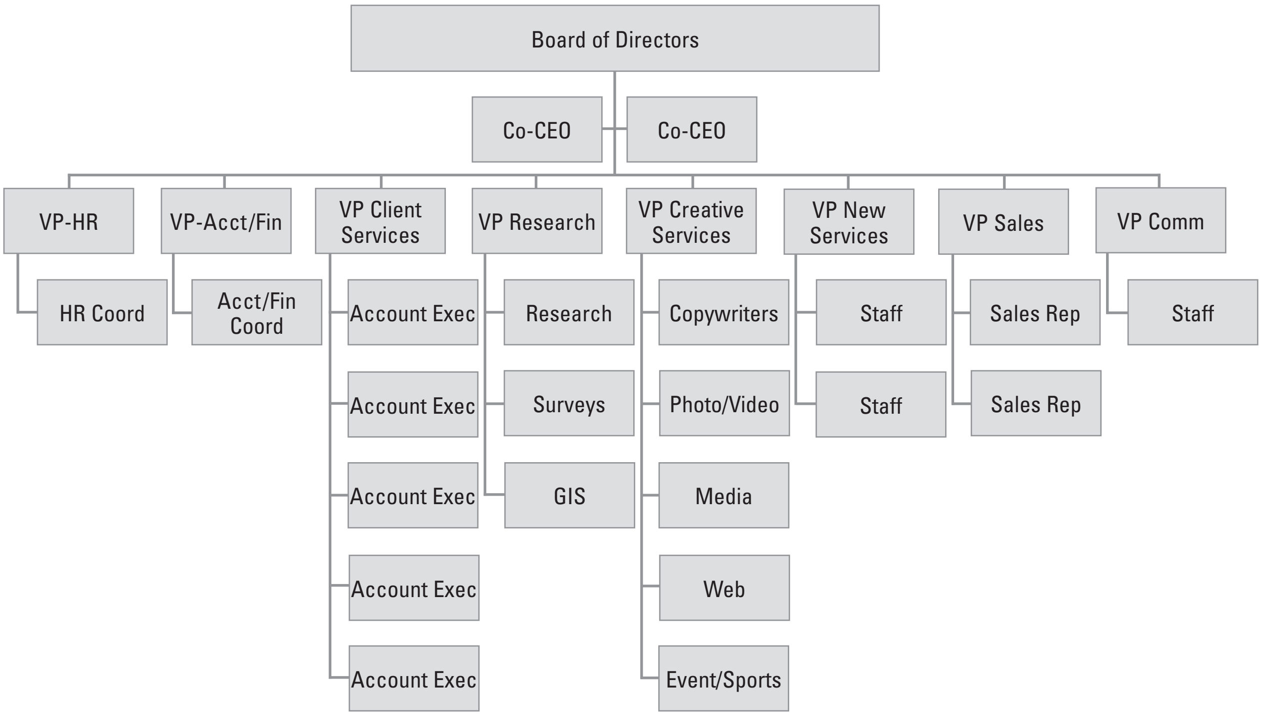
Any institution that might adopt this idea will need to handle this issue.

Research and Creativity: Scaffolding Skills

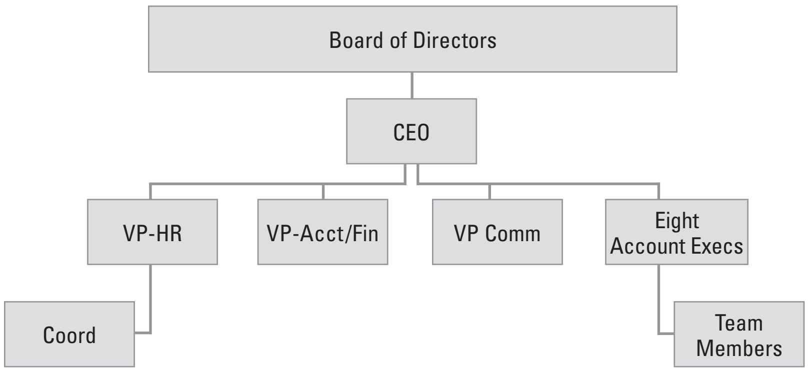
Not every project contracted by Velocity is a formal research project. Only some of the work qualifies as formal research or a creative activity. Regardless of project focus, students learn about research ideas, methods, and concepts during the discussion of projects at the weekly staff

FIGURE 2. Organizational Structure

Original Organizational Structure



Revised Organizational Structure



meetings. Through this process, they build a vocabulary and understanding of what research entails as well as an appreciation for research as a realm that encompasses the academic private sectors. Through their work on Velocity projects, students can see how research supports organizational goals. Work in Velocity prepares students for their required senior thesis project, and some of the findings of the organization have been presented at academic meetings that highlight a theory-to-practice approach.

Building Velocity at Carthage and in Other Contexts

Velocity has been an important addition to the undergraduate research portfolio at Carthage. It has required a relatively low financial commitment and has engaged students in research in some significant and public ways. It has relied on the energy and expertise of students across departments to run the organization. Others interested in adopting this model should be reminded that it should be adapted to the specific institutional context. Given the difficulty of funding research through traditional external and internal methods, this model presents an attractive alternative to traditional student organizations, as it has the possibility of becoming self-sustaining.

Students report that they have benefited in significant ways. Testimonials received express the students' sense of personal growth and development as well as their sense that the experience assisted them in finding work or

FIGURE 3. The Students Involved in Velocity Consulting

obtaining acceptance to graduate school. It is important to quantify the qualitative information gathered. Now that a sustainable economic model seems to have been established, one of the next tasks will be to assess student development outcomes. The projects with student involvement integrate many high-impact practices (Kuh 2008), and it is likely that the impact of the Velocity experience will be evident in the assessment data.

This kind of model expands the capacity for an institution to fund both undergraduate research projects and scaffold undergraduate research skills. The model presented here is not the only way to build a self-funded student organization, but it offers an example for thinking beyond the traditional funding mechanisms that have been a mainstay over the years.

References

Bennis, Warren G., and James O'Toole. 2005. "How Business Schools Lost Their Way." *Harvard Business Review* 83(5): 96–104.

Boyer, Ernest L., Drew Moser, Todd C. Ream, and John M. Braxton. 2015. *Scholarship Reconsidered: Priorities of the Professoriate, Expanded Edition*. San Francisco: Jossey-Bass.

Chamely-Wiik, Donna, Kimberly Dunn, Patricia Heydet-Kirsch, Mirya Holman, Daniel Meeroff, and Jennifer Peluso. 2014. "Scaffolding the Development of Students' Research Skills for Capstone Experiences: A Multi-Disciplinary Approach." *CUR Quarterly* 34(4): 18–25.

Ghoshal, Sumantra. 2005. "Bad Management Theories Are Destroying Good Management Practices." *Academy of Management Learning & Education* 4(1): 75–91. doi: 10.5465/amle.2005.16132558

Hawawini, Gabriel. 2005. "The Future of Business Schools." *Journal of Management Development* 24: 770–782. doi: 10.1108/02621710510621286

Kuh, George D. 2008. *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter*. Washington, DC: Association of American Colleges and Universities.

Levesque-Bristol, Chantal, Timothy D. Knapp, and Bradley J. Fisher. 2010. "The Effectiveness of Service-Learning: It's Not Always What You Think." *Journal of Experiential Education* 33: 208–224. doi: 10.5193/jee33.3.208

Mintzberg, Henry. 2004. *Managers, not MBAs: A Hard Look at the Soft Practice of Managing and Management Development*. Oakland, CA: Berrett-Koehler.

Prentice, Mary. 2007. "Service Learning and Civic Engagement." *Academic Questions* 20: 135–145. doi: 10.1007/s12129-007-9005-y

Raelin, Joe. 2006. "Does Action Learning Promote Collaborative Leadership?" *Academy of Management Learning and Education* 5: 152–168. doi: 10.5465/amle.2006.21253780

Julio Rivera
Carthage College, julio@carthage.edu

Joseph J. Shields is a professor of marketing and management at Carthage College. He has served as an executive at several major corporations, including Miller Brewing Co., ABB Robotics, and Snap-on Tools. He is a founder and board member of the student-run Velocity Consulting. He also owns a real estate investment company and consults for nonprofit and for-profit businesses across southeast Wisconsin.

Julio Rivera is a professor of management, marketing, and geospatial science at Carthage College, and he regularly serves as a consultant to colleges and universities as they develop undergraduate research programs. Rivera also works as a consultant to both government and businesses in southeast Wisconsin. He returned to faculty life in 2014 after serving as the provost at Carthage.

Joseph M. Wall is a professor of accounting at Marquette University. He is regularly presents on topics involving financial injustice and financial imbalances. He is a founder of Velocity Consulting and owns his own investment firm and consults nationally in the area of cyber forensics. Prior to joining Marquette, Wall was an assistant professor at Carthage College, serving four years as a department chair.

PRACTICE

A Research-Infused Undergraduate Music Curriculum

Gregory Young, *Montana State University*
Gary W. Don, *University of Wisconsin–Eau Claire*
Alan Rieck, *Pennsylvania State University*

Abstract

As music programs at colleges and universities join the undergraduate research movement, many faculty and administrators may be unsure of terminology, educational practices, or ways to combine some of the creative aspects of music degree requirements into compelling undergraduate research projects. One of the biggest challenges is embedding undergraduate research and creative activity (URSCA) into the curriculum so that more students experience it without placing additional burdens on faculty. This article offers examples within the music degree and general education requirements at two universities that might serve as models. They range from freshman year to senior capstone projects, offering students inspiring and active learning experiences that will enhance their engagement with the subject matter and link their learning with the discovery of knowledge and art.

Keywords: *creativity, research, music, senior capstone, general education, interdisciplinary, seminar*

doi: 10.18833/spur/1/1/3

Music has been one of the last disciplines to embrace undergraduate research (UR), as many instructors across the country either do not know about the growing undergraduate research activity nationally or are reluctant to join in. Many others are mentoring undergraduate research but simply not labeling it as such. Still others have not combined the various elements of student creativity into projects that could be recognized as research. This article describes several efforts at Montana State University (MSU) and the University of Wisconsin–Eau Claire (UWEC), offering suggestions that could be applied at other institutions. URSCA is a requirement in general education at the former and a path to general education at the latter institution.

Terminology

The Council on Undergraduate Research (CUR 2017) defines undergraduate research as follows: "An inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline." Reactions to this definition by faculty members in music have included the following:

1. "My students are not prepared to make an original intellectual or creative contribution to the discipline";
2. "I am too busy teaching the basics to mentor students in this way"; and
3. "Undergraduate research is something that works better in the sciences" or, conversely, "Everything we do in music is a creative activity."

One way to think about the definition of UR for music is what a music department might recommend if asked for student submissions in a campus-wide undergraduate research/creativity symposium. They would likely recommend the best original student projects from courses or independent studies that bring recognition to the music department. It could be an original composition, an exemplary final paper for a music history seminar, a survey of community music participation, or examples that will be discussed later in this article. Celebrations of student work are almost ubiquitous now at colleges and universities across the United States, and it is in the best interest of every music unit to participate as fully as possible.

Ultimately the research and creative process is the inquisitive and disciplined pursuit of answers to a particular question. Too frequently research is viewed as the acquisition of knowledge rather than as a process through which assumptions and possibilities are questioned and explored so as to reveal, reaffirm, or call into question what one thinks is already known. When a relevant question guides inquiry, scientists and artists are empowered to make meaningful connections that are more easily integrated into the greater scheme of knowledge and understanding. Artistically, these questions regularly explore the realities and possibilities of human experience. What does it mean to experience loss? How does one express the realities of joy to others? What impact does cultural context have on the manner of expression of its constituents?

A prerequisite for adopting UR fully into the curriculum is to ensure that all, or most, faculty members in the department or school are on board. This could be introduced as part of strategic planning; be incorporated into the vision and mission statements; be the goal of the curriculum committee, or all of the above. Scaffolding UR so that students are exposed to the concepts in freshman seminar, experience it in some way in most music courses and in the general education component, and finish with a senior project focused on UR would constitute a research-infused curriculum.

Embedding Undergraduate Research in the Music Curriculum

The music major seminar at the MSU School of Music is a weekly zero-credit offering that complements the standard concert attendance requirement. In this seminar, faculty and others present their research in an interactive way, with plenty of time for questions and answers. Students would learn, from the beginning of their degree programs, that professors do more than just teach and that universities are often the leading generator of new knowledge, including music composition. An example played out in this music major seminar in January 2016. The clarinet professor (Young) was planning the fall recital "The Clarinet in Rare Contexts" and led a collaborative composition session with a didgeridoo player (from the science faculty), and an undergraduate percussionist. After demonstrating the traditional possibilities on each instrument, the players asked the music majors in the audience for ideas for innovative sound-making, themes and structures for a composition, ways to start the piece, and so forth. The result was a four-movement sketch with the following spontaneous working titles:

I. Sunrise Sounds,
II. The Wild Jungle,
III. Conflict, and
IV. Sunset Serenity.

Students suggested singing into the clarinet while playing, emitting primitive screams into the bottom of the djembe, and rubbing the didgeridoo ribs with a stick, as well as offered other wild ideas that have yet to be refined. The session provided a fun way to spend an hour with the music majors, insight into uninhibited creativity, and some great compositional ideas.

In most courses, music professors could spend part of their instructional time or provide an assignment that involves passing on new research relevant to the course material. At first glance, this activity may seem unrealistic, but with a little creativity, it can be done. For example, in woodwind methods classes, the professor could introduce new research about reeds and even have students collect empirical data on the sounds of different reeds. Applied music instructors could have students bring in discussion topics from the latest instrument-based publications or web resources. Millennial students especially appreciate knowing that they are up-to-date with the latest knowledge in their studies.

Undergraduate Research in General Education

A robust general education program should have inquiry, undergraduate research, and the discovery of knowledge as major foci. The "Core 2.0" general education program at MSU requires its 14,000 undergraduate students to choose and complete four inquiry courses and a research/creative experience course. At UWEC, an integrative learning (IL) component recently was implemented as part of the university's liberal education requirement that is replacing its general education requirement. Integrative learning offers opportunities for scaffolding undergraduate research as part of regular coursework. The IL rubric has three benchmarks:

1. [Each] student demonstrates a developing sense of self as a learner by connecting academic knowledge to [his/her] own experiences;
2. [Each] student makes connections across disciplines; and
3. [Each] student applies skills, knowledge, or methodologies gained in one academic or experiential context to a different academic or experiential context.

The UWEC Department of Music and Theatre Arts proposes that students can meet the three IL rubric requirements by developing research questions that they pursue over the course of three or more separate classes. The connections among the students' experiences in these different contexts combine to satisfy the three rubric requirements. For example, a student may ask how Mozart developed real characters in his operas. This student, who may be performing a role in a Mozart opera, can analyze the melodic, harmonic, and formal aspects of the arias that he or she is performing in a music theory class. The broader context of gender roles, operatic conventions, and the social context for the opera can be examined in a music history course. The student can then use this knowledge to shape his or her performance of the role in the opera, thus “connecting academic knowledge to [his or her] own experiences” and demonstrating the connection of these areas in the development of the character in performance. The student’s research thus fits into existing courses and the workload of the faculty member, without additional demands on faculty time.

Interdisciplinarity

Electives that offer interdisciplinary perspectives on research at MSU have included seminars on music and architecture, music and economics, and music and the brain. Although these are more difficult to fit into existing faculty workloads, they can help propel faculty research due to the likelihood of resulting publications and might be eligible for funding from an honors program or other strategic initiative from the institution. These interdisciplinary student-faculty research projects can address faculty concerns about the difficulty inherent in identifying projects that are appropriate for undergraduate students, because they do not require disciplinary knowledge and skills at the doctoral level. The students can contribute knowledge from different disciplines to the project that might not be known by the faculty member. In this way, the students are genuine collaborators. One example from UWEC is a music-mathematics project examining sound synthesis of fractal shapes. The faculty member (Don) contributed knowledge of sound synthesis tools such as C Sound, and the student contributed knowledge of affine transformations and mathematics tools such as Matlab. By combining and connecting their knowledge and skills acquired from different disciplines, the researchers were able to explore the analogies between visual and sonic shapes in new ways. The initial results of the research were presented at the National Conference of Undergraduate Research (NCUR), but the value of the research extended far beyond that venue. It led to collaborations between faculty and students in music and mathematics, resulting in a book and numerous student-faculty summer research projects based on other connections between music and mathematics (Walker and Don 2013).

Community-based research projects, whether as paid internships or credit-bearing independent studies, fit naturally within a research-infused music program. Examples include a business major working on marketing research for the local symphony; innovative event planning for a community arts organization; surveying the participants in community music lesson programs; or researching the relationships between music and memory at an elder care facility. Even study abroad can afford students the opportunity to conduct research, and funding from a central university research office for the project could help offset travel costs for students. Very often, music students are the least likely to apply for central funding available to students for research, but most central office UR personnel strive to have a wide representation of disciplines.

One faculty member (Young) gave an assignment to students in a leadership seminar that involved reading a publication by an MSU professor on any subject of interest, calling the professor, and requesting a 15-minute interview. Students then wrote a short paper encompassing the interview and the professor’s research and created a five-minute presentation on it for class. Professors were delighted that these students were reading their publications and happy to discuss their research with them. The learning outcomes associated with this small project involved performing a literature search, technical reading, gaining the confidence to call a professor and interview him or her, writing about the experience, and presenting to peers. One observation was that students had little prior knowledge of the roles of professors outside of teaching. Such an activity can assist in creating an educated citizenry who not only vote but also become future leaders in the community and beyond.

Senior Capstone

The required senior capstone project at MSU is taught by Young and is structured as a collection of undergraduate research projects mentored by the instructor with or without additional mentoring by professors interested in the particular topics. These can be independent projects or small parts of a professor’s research in which the student acts as a research assistant. Examples of independent projects include the following:

1. Nicole Jerominski Krause built a small marimba using only leftover materials from a building construction site, documented this project on video, and presented her findings—and the marimba—at NCUR; and
2. Anthony Gaglia spent time in Haiti, decided to research Haitian musical genres, and composed an original piece for five guitars.

Examples of work involving a professor’s research include the following:

1. Samantha Tschida worked on a research project with Young surveying students and faculty about the benefits of learning to perform from memory. The resulting article was published in a national journal (Young 2003) and reprinted in two German journals (Young 2004, 2006); and
2. Madison Gabig interviewed faculty members from music and other disciplines about teaching creativity. Her work is part of a book chapter currently in press (Young, forthcoming).

Even though faculty workload issues are perhaps the toughest to work out in the transition to a research-infused music curriculum, a little creativity paired with the knowledge that students will benefit can reap great rewards. Students will realize that they can pursue a modern degree centered on their interests and linked to the creation of knowledge and art, and will be better prepared to adapt to real-life situations after graduation.

References

Council on Undergraduate Research (CUR). 2017. "About the Council on Undergraduate Research." Accessed June 24, 2017. http://www.cur.org/about_cur/

Walker, James S., and Gary W. Don. 2013. *Mathematics and Music: Composition, Perception, and Performance*. Boca Raton, FL: Taylor & Francis.

Young, Greg. 2003. "The Benefits of Learning to Perform from Memory." *NACWPI (National Association of College Wind and Percussion Instructors) Journal* 51(1): 14–16.

Young, Greg. 2004. "Auswendigspielen – ein wichtig Bestandteil der musicalischen." *TIBIA – Magazin fur Holzblaser* 3: 185–186.

Young, Greg. 2006. "Auswendigspielen – ein wichtig Bestandteil der musicalischen Entwicklung." *Rohrblatt: Magazin für Oboe, Klarinette* 2: 76–77.

Young, Greg. Forthcoming. "Creative Interdisciplinarity in the Arts." In *Exploring, Experiencing, Envisioning: Integration in the Arts*," ed. Nancy Hensel. New York: Palgrave.

Gregory Young
Montana State University, gyoung@montana.edu

Gregory Young is a professor of music theory and clarinet at Montana State University where he was vice provost for undergraduate education for eight years and founding director of the Undergraduate Scholars Program. He supervised the implementation of a new core curriculum that was one of the first at a public university to require undergraduate research/creativity. Young often publishes with undergraduate coauthors and has given invited talks in Italy, Spain, and the United States on correlations between music and architecture. He is a former treasurer and chair of the National Conferences on Undergraduate Research. He serves as a councilor in the Arts & Humanities division of CUR and as a member of the steering committee for the British Conference of Undergraduate Research.

Gary W. Don is a professor of music theory at the University of Wisconsin–Eau Claire. He teaches second-year written theory and aural skills, as well as upper-division theory courses. He also sponsors independent and collaborative student research projects. He holds a doctorate in music theory from the University of Washington, and he taught theory and aural skills at Skidmore College before joining the UWEC faculty. His research interests include overtone structures in the music of Debussy, modality in the music of Prokofiev, and theory pedagogy. He has presented papers on these topics at the West Coast Conference of Theory and Analysis, Music Theory Midwest, the Great Lakes Chapter and national conferences of the College Music Society, and national meetings of the Society for Music Theory. He has published articles in Computer Music Journal, In Theory Only, Perspectives of New Music, Music Theory Spectrum, *and* Musical Insights*, as well as an essay in* Analyzing the Music of Living Composers (and Others), *Cambridge Scholars Publishing.*

Alan Rieck is assistant vice president and assistant dean for undergraduate education at Penn State University. He is a member of the leadership team in the Office of Undergraduate Education that provides collaborative direction and coordination for university-wide programs and initiatives in support of undergraduate teaching, learning, and enrollments at Penn State. His responsibilities include leadership and administration of undergraduate research and other program initiatives, collaboration and coordination for university groups and initiatives concerned with undergraduate education issues, leadership and coordination for strategic planning in undergraduate education, and oversight for undergraduate education communications. Rieck was previously professor of choral music and music education as well as chair of the UWEC Department of Music and Theatre Arts.

Undergraduate Research Highlights

Higby KJ, Bischak, MM, Campbell CA, Anderson RG, Broskin, SA, Foltz LE, Koper JA, Nickle AC, Resendes KK. 5-Flurouracil Disrupts Nuclear Export and Nuclear Pore Permeability in a Calcium Dependent Manner. *Apoptosis: An International Journal on Programmed Cell Death*. 2017; 22:3: 393–405. doi: 10.1007/s10495-016-1338-y. (Westminster College, New Wilmington, PA)

Our results revealed a new mechanism of action for the chemotherapeutic 5-flurouracil (5-FU) in combination with other drugs such as topotecan during apoptosis. Specifically we found that 5-FU alters nuclear transport early in apoptosis in a calcium-dependent manner. This alteration can be used to target cancers where overactive nuclear export contributes to transformation and to counteract drug resistance where chemotherapy targets such as topoisomerase need to be maintained in the nucleus. Our results also open the door to other potential combination chemotherapies that employ 5-FU. Karen Resendes is an associate professor of biology and co-director of the Drinko Center for Undergraduate Research at Westminster College. Kelly Higby worked on this project in 2014–2016 as part of honors research and is currently employed at the Dana Farber Cancer Institute. Melissa Bischak worked on this project in 2015–2016 as part of honors research and is applying to physician assistant programs. Christy Campbell and Rebecca Anderson worked on this research in 2014–2015 as capstone research and independent study; Campbell is currently employed at CookMyosite, and Anderson is a second-year graduate student at Wake Forest University. Sarah Broskin worked on this project in 2013–2014 as capstone research and independent study and is a first-year graduate student at Drexel University. Lauren Foltz worked on this project in 2012–2013 as capstone research and independent study and is a fourth-year graduate student at University of Montana. Jarrett Koper worked on this project in 2016 as capstone research and will attend medical school at LECOM next year. Audrey Nickle worked on this project in 2016–2017 as part of honors research, is applying for summer research internships, and will apply to graduate school next fall. This research was supported by the Westminster College Drinko Center for Undergraduate Research (each student was awarded a research or travel grant) and the Dietz-Sullivan Biology Research Experience Award (Resendes and Higby).

Aronson HS, Zellmer AJ, Goffredi SK. The Specific and Exclusive Microbiome of the Deep-Sea Bone-Eating Snail, *Rubyspira osteovora*. *FEMS Microbiology Ecology.* 2017; 93(3): fiw250. doi: 10.1093/femsec/fiw250. (Occidental College)

Rubyspira osteovora is an unusual snail, found only on bones of decomposing whales in the deep sea. This study characterized the very low-diversity gut microbiome of *R. osteovora*, compared to the surrounding environment, as well as to other deep-sea snails with more typical diets. The microbiome of *R. osteovora* is dominated by microbes not observed in either the environment or within other non-bone-feeding gastropods. This specificity, as well as the temporal stability of the microbiome over six years, indicates a microbiome that is exclusive to *R. osteovora*. By considering the microbial community nested within marine animals, we will surely discover more about the reciprocal influence these organisms have on each other and further increase our understanding of biodiversity in deep-sea ecosystems. Shana Goffredi is an associate professor of biology (researching microbial symbiosis), and Amanda Zellmer is an assistant professor of biology (specializing in computational biology). Heidi Aronson wrote the paper as part of her honors project in biology during her senior year (2016). Now interviewing for graduate school in microbiology, she is a research scientist at the Jet Propulsion Lab in Pasadena. This research was partially supported by a Howard Hughes Medical Institute grant to Occidental College and the Undergraduate Research Center (Academic Student Projects) at Occidental College.

Silverberg LJ, Tierney J, Pacheco C, Lagalante A, Bachert JT, Bayliff JA, Bendinsky RV, Cali AS, Chen L, Cooper AD, Minehan MJ, Mroz CR, Noble DJ, Weisbeck AK, Xie Y, Yang Z. Synthesis and Spectroscopic Properties of a Series of Novel 2-aryl-3-phenyl-2,3-dihydro-4H-1,3-benzothiazin-4-ones. *ARKIVOC*. 2016; 6: 122-143. doi: 10.3998/ark.5550190.p009.875. (Pennsylvania State University, Schuylkill Campus)

Compounds with a 2,3-dihydro-4H-1,3-benzothiazin-4-one scaffold have shown a wide range of bioactivity. In the present study, a series of 13 novel 2-aryl-3-phenyl-2,3-dihydro-4H-1,3-benzothiazin-4-ones was prepared at room temperature by T3P-mediated cyclization of N-phenyl-C-aryl imines with thiosalicylic acid. The spectral and physical properties were studied and are reported and discussed. Lee Silverberg is an associate professor of chemistry at Penn State Schuylkill, and John Tierney is a professor of chemistry at Penn State Brandywine. Carlos Pacheco is an NMR spectroscopist at Penn State University Park. Anthony Lagalante is a professor of chemistry at Villanova University. Joshua Bachert is pursuing a bachelor's degree in mechanical engineering at Penn State Harrisburg. J. Austin Bayliff is a project engineer at

Pratt and Whitney in Hartford. Ryan Bendinsky is a field service engineer at Agilent Technologies in Aberdeen, MD. Aaron Cali is a mechanical systems designer at H. T. Lyons in Fogelsburg, PA. Liuxi Chen is enrolled at Penn State as an undergraduate. Avril Cooper is enrolled in a public health certificate program and is in the process of applying to medical school. Michael Minehan is pursuing a master's degree in biomedical engineering at Cornell University. Caitlin Mroz is studying biology at Penn State, where she works digitizing insect specimens at the Frost Entomological Museum. Duncan Noble is a biology major at Penn State Schuylkill. Alex Weisbeck is still an undergraduate student at Penn State. Yiwen Xie recently graduated from Penn State and plans to work in China. Ziwei Yang is currently enrolled in an undergraduate program in biochemistry at Penn State University Park. Funding was provided by Penn State Schuylkill and SP Controls, Inc.

Cardona J, Barclay S, Izquirdo K, O'Hagan K, Raines D. Partnering for Evidence-Based Practice. *Neonatal Network: The Journal of Neonatal Nursing*. 2017; 36: 2: 107–109. doi: 10.1891/0730-0832.36.2.107. (Sisters of Charity Hospital and University at Buffalo)

This column outlines the process and perceived benefits of nursing students and practicing nurses partnering to bring evidence-based practices to the clinical setting. The perspective of both the practicing nurse and the nursing student are shared. This work illustrates the importance of socializing students to the professional role of the nurse during prelicensure nursing education as well as promoting the professional growth of practicing nurses. Deborah Raines is associate professor of nursing and the Dedicated Education Unit faculty member at Sisters of Charity Hospital. Julie Cardona is a mother-baby nurse at Sisters of Charity Hospital. Sarah Barclay, Kimberlie Izquirdo, and Kristy O'Hagan were juniors enrolled in the junior clinical practice course focused on maternal newborn nursing at the time this column was written. All three graduated from University at Buffalo with BSN degrees in May 2016. This work was part of the partnership between the University at Buffalo School of Nursing and the Nursing Leadership at Sisters of Charity Hospital.

Horan K, Schap D. State Variation in Certain Rules Governing Expert Witness Testimony. *Journal of Legal Economics*. 2016; 23: 1: 61–70. (College of the Holy Cross)

State statutory laws differ relative to four federal rules that govern expert witness testimony in federal courts. The state variation is classified as of mid-2016 and presented in tabular form. The tables show (a) state practices consistent with one or more of the federal rules; and (b) common and less common departures from the federal rules. David Schap is professor of economics. Kayla Horan, Holy Cross Class of 2018, participated in the research as a research assistant and coauthor during summer 2016. Horan spent fall 2016 as an academic intern at the Brookings Institution in Washington, DC, and has now returned to her studies at Holy Cross. The Office of the Dean at Holy Cross provided funding for summer research in 2016.

O'Toole TM, Graham KG, Jones TN. *N*-(3-Trimethylsilyl) Propargyl Amino Esters via Reductive Amination. *Tetrahedron Letters*. 2017; 58: 12: 1230–1232. doi: 10.1016/j.tetlet.2017.02.032. (College of St. Benedict/ St. John's University)

This work provides ready access to N-(3-trimethylsilyl) propargyl amino esters via reductive amination in good to excellent yields. Esters of all 20 naturally occurring amino acids and phenylglycine were studied. Propargylation was observed for all amino esters except for that derived from cysteine. A highlight of this work is that no additional protecting groups were required for amino esters possessing nucleophilic side chains. Kate Graham and T. Nicholas Jones are associate professors of chemistry. Thomas O'Toole completed this work as part of the 2015 Summer Chemistry Department Undergraduate Research Program at CSB/SJU. O'Toole plans to begin medical school in fall 2017. This work was funded by the CSB/SJU Undergraduate Research Program and the Abbot John Klassen Research Fund.

Bhattacharyya TK, Hsia Y, Weeks DM, Dixon T, Lepe J, Thomas JR. Association of Diet with Skin Histological Features in UV-B-Exposed Mice. *JAMA Facial Plastic Surgery.* 2017; 1. doi: 10.1001/jamafacial.2017.0060. (University of Illinois at Chicago)

This study pursued the question of whether there is any dietary influence on UV-B–induced changes in skin histological features. In this animal study, long-term UV-B irradiation was administered to the dorsal skin in mice-fed normal, calorie-restricted, and obesity diets. Histopathological changes were monitored with light microscopic morphometry and immunohistochemistry. Dietary modulation of skin histological response to UV-B irradiation was observed. Tapan Kumar Bhattacharyya is a research assistant professor, Yvonne Hsia is a visiting research specialist, Tatiana Dixon is an assistant professor and director of clinic facial plastic surgery, and J. Regan Thomas is Mario D. Mansueto Professor and department head in the Department of Otolaryngology at the UIC College of Medicine. David M. Weeks is a facial plastic and ENT surgeon at Wellstar in Marietta and East Cobb, Georgia.

Jessica Lepe graduated in December 2016 with a degree in biological sciences. Lepe's participation was funded by a Chancellor's Undergraduate Research Award from the Office of Undergraduate Research at UIC.

Jaye JA, Gelinas BS, McCormick GM, Fort EH. Implications of the Final Ring Closure to 10b-aza-10c-Borapyrene for Aryl–Alkyne Ring-Closing Mechanisms. *Canadian Journal of Chemistry*. 2017; 95: 4: 357–362. doi: 10.1139/cjc-2016-0477. (University of St. Thomas)

Through a combined computational and isotopic labeling study, the aryl–alkyne ring closure of the azaborine containing 4-ethynyl-4a-aza-4b-boraphenanthrene was found to proceed via an alternate mechanism than that of its hydrocarbon analog. This catalyst-free reaction proceeds at modest reaction conditions compared with traditional pyrolytic synthetic methods and holds promise for the efficient construction of fused ring systems containing azaborine functional groups. Eric H. Fort is an associate professor of chemistry. Joseph Jaye is enrolled in a doctoral program in chemistry at UCLA, and Benjamin Gelinas is enrolled in a doctoral program in food chemistry at Ohio State University. Grant McCormick will be attending University of Nebraska's College of Medicine in fall 2017. This work was supported by the University of St. Thomas, the University of St. Thomas Grants and Research Office, and the donors of the American Chemical Society Petroleum Research Fund.

Book Review

Research-Based Learning: Case Studies from Maastricht University

Edited by Ellen Bastiaens, Jonathan van Tilburg, and Jeroen van Merriënboer

Springer Professional Learning and Development in Schools and Higher Education Volume 15

Springer International Publishing AG, Cham, Switzerland, 2017. vii + 219 pages.

Hardcover ISBN: 978-3-319-50991-4

eBook ISBN: 978-3-319-50993-8

Reviewed by Susan Berry Brill de Ramírez, Bradley University, brill@bradley.edu

doi: 10.18833/spur/1/1/6

Research-Based Learning: Case Studies from Maastricht University, edited by Ellen Bastiaens, Jonathan van Tilburg, and Jeroen van Merriënboer, introduces the university's honors program in research-based learning (RBL), the theoretical models and key concepts of RBL at the undergraduate level upon which the program is based, and case studies from a diverse range of departments and programs. The competitive and selective RBL program for third-year students at Maastricht University in the Netherlands was developed with national higher education funding "to create new educational formats to challenge excellent students" (174). Maastricht already had a strong track record of pedagogical innovation with problem-based learning (PBL) as a core educational model across the university, which was discussed in *CUR Quarterly* (E. Bastiaens and J. Nijhuis, "From Problem-Based Learning to Undergraduate Research: The Experience of Maastricht University in the Netherlands," 32.4 [2012]: 38–43). Through the book, the editors seek to encourage and assist other institutions and departments in their RBL initiatives.

The volume begins with Roeland van de Rijst's comprehensive "The Transformative Nature of Research-Based Education: A Thematic Overview of the Literature," which highlights the pedagogically transformative experiences of RBL when learning objectives are aligned with teaching strategies to develop "effective instructional design of RBL opportunities" (4–5). However, the evidence shows that "research-teaching links do not come about naturally, . . . [requiring] focused, purposeful, and persistent institutional strategies" to implement successful undergraduate RBL programs (13). The editors' second and third chapters turn to the development of the institutional commitment to and practice of RBL at Maastricht University. Chapter 2 lays out the historical process, beginning with the European Union's 1999 commitment to improved higher education through establishing a cross-border higher education area by 2010. The university then developed the MaRBLe (Maastricht Research-Based Learning for Excellence) programs that feature inquiry-based/problem-based learning. Chapter 3 introduces the "Three Educational Models for Positioning the Maastricht Research-Based Learning Programme." The next nine chapters provide case studies from the MaRBLe programs at Maastricht.

In chapter 4, "Faculty of Psychology and Neuroscience: The Psychology Student as Researcher," Herco Fonteijn and Arie van der Lugt discuss how talented and motivated students are selected to build on their content-based learning and research methodology group experience and "plan, conduct, and present their own individual research project under the supervision of a faculty member" (49), which has led to a number of scholarly publications. Challenges included various levels of student commitment and limited resources such as insufficient lab space for undergraduate researchers. Chapter 5, "Faculty of Arts and Sciences: The Adventure of Doing Research," by Pieter A. J. Caljé turns to the programs in European studies and arts and culture that are largely content and textbook based. For humanities students, RBL was a foreign concept and required active peer review as part of a cohesive academic community of student researchers; faculty supervisors acted as collaborators who shared their own research methods and suggested possible topics for the students to pursue.

Chapters 6–12 present additional case studies, including RBL as part of small tutorials in which "students and their supervisors were co-learners in the process of academic inquiry" (82), collaborations where students conducted research with partners in the private and public sectors to work on real-world problems (such as sustainable sanitation), RBL initiatives where the student is viewed as an apprentice to a faculty researcher, science research beyond monodisciplinary boundaries, faculty projects involving undergraduates in higher level research, conference presentations of bachelor theses at university or external academic venues, and competitively selected student research for presentation at a university symposium. The institutional commitment broadened support and implementation of RBL opportunities across campus, including the fields highlighted in the volume such as psychology and neuroscience, arts and sciences, business and economics, and law.

The final chapters offer evaluations of the Maastricht program. In chapter 13, "The Effectiveness of the MaRBLe Programme: Evaluation Findings," Bastiaens, Jimmie Leppink, and van Merriënboer explain that they were interested in students' "social interaction with academic staff and the extent to which students felt motivated and enjoyed conducting research on a topic of their interest" (174), but the inconsistency of program assessment data collection limited the conclusions that could be drawn. The researchers affirmed that they "should have thought of evaluation methods that are sustainable in the long run at an earlier stage" (182). In chapter 14, "Reflection and Lessons Learned," the editors present their conclusions regarding the five-year program, noting the importance of dialogue at all stages, peer review for time management and task completion, research guidance and mentors, and external stakeholders for student motivation and research innovation.

At Maastricht, it was understood that successful research requires a substantive commitment. This meant that its MaRBLe program was targeted to the top 25 percent of students, along with selected others who fell below this level but who were highly motivated. Although there were concerns regarding elitism and desires for wider access to RBL, it was recognized that a viable program would depend on motivated students who were committed to the success of their research projects. This volume provides an invaluable introduction for educators and administrators interested in the implementation of institutional, departmental, and faculty-led RBL initiatives. The book also includes an appendix that lists many of the students' publications and other special achievements.

SPUR SCHOLARSHIP AND PRACTICE OF UNDERGRADUATE RESEARCH

The Journal of the Council on Undergraduate Research

SUBMISSION GUIDELINES

Scholarship and Practice of Undergraduate Research (SPUR) publishes scholarly work that examines effective practices and novel approaches, explores pedagogical models, and highlights the results of assessment of undergraduate research. As a peer-reviewed publication of the Council on Undergraduate Research, the journal provides useful and inspiring information that increases our understanding of undergraduate student-faculty engagement in research, scholarship, and creative work in all disciplines and at all types of higher education institutions in the United States and abroad.

General Criteria

Scholarship and Practice of Undergraduate Research (SPUR) publishes articles relating to all aspects of undergraduate research that are of interest to a broad readership. Articles regarding the effects of the research experience on the development and subsequent endeavors of students, as well as how to initiate, support, or sustain undergraduate research programs, are appropriate for this journal. SPUR is not the appropriate venue for publishing results of undergraduate research.

Manuscripts that are unrelated to undergraduate research or focus on the success of an individual or institutional undergraduate research program without providing a substantive presentation of goals, strategies, and assessed outcomes related to the program are not suitable for publication. Manuscripts that describe novel programs that can serve as models for other institutions, those containing significant assessment of outcomes, and those articulating research on the efficacy of undergraduate research programs are particularly suitable for publication in SPUR.

Editorial Policies

SPUR is the voice of members of the Council on Undergraduate Research. All articles are peer-reviewed. Editorial judgment regarding publication of manuscripts and letters rests with the Editors. Concerns about editorial policies and decisions should be addressed to the editors.

Manuscripts

How to Submit

Authors are encouraged to discuss disciplinary articles with the appropriate division editor prior to submission. Contact information for all editors is listed in every issue of SPUR. Submissions should be made at the SPUR online submission site, http://spur.msubmit.net.

Materials to Submit

- Copy of article (MS Word or compatible format, 12-point Times font, double-spaced, 1-inch margins, and single-spacing between sentences). The typical length of an article is 2000–3500 words, but longer or shorter articles may be appropriate for certain topics. Citations must be in author-date format, *Chicago Manual of Style* (refer to http://www.chicagomanualofstyle.org/tools_citationguide.html).
- Abstract
- Keywords for indexing (up to 10)
- Personal information (include institutional title, mailing address, and email address for the corresponding author and a short biographical sketch for each author)

Book Reviews

SPUR publishes short reviews of books and other new publications the editors deem of interest to the undergraduate research community. Books or other publications will be reviewed within 12 months of publication. The book review editor will select appropriate titles for review and solicit reviewers. To ensure that the reviews are as timely as possible, the book review editor will expect to receive finished reviews within two months of assignment. Each printed issue of SPUR will include one review.

Suggested titles for review and book reviews should be submitted via email to:

Susan Berry Brill de Ramirez
Book Review Editor
Bradley University
brill@fsmail.bradley.edu

CUR Comments

SPUR will consider for publication scholarly commentaries from readers on issues vital to the health and vigor of the undergraduate research enterprise. *CUR Comments* should be limited to 250 words and must be on topics relevant to CUR's mission. *CUR Comments* will be published at the sole discretion of the editors and will be edited if necessary. The writer will be shown the edited version for her/his approval.

Undergraduate Research Highlights

Undergraduate Research Highlights consist of brief descriptions of peer-reviewed research or scholarly publications in scholarly journals that have been published within the past six months. These publications must be in print and must include one or more undergraduate coauthors. Calls for submissions are disseminated quarterly and posted on the CUR website. Highlights appear in SPUR and in an online CUR database (http://www.cur.org/publications/undergraduate_research_highlights/).

Submissions should include:

- Title of the article and full journal citation (inclusive pages).
- A brief description (3-5 lines) of the research and its significance.
- Title and department or program affiliation of the faculty member.
- A brief description of the student coauthor(s). Include the year of study in which the student(s) undertook the work, the opportunity through which the work was undertaken (independent study project, summer project, REU program, senior thesis project, etc.), and the current status of the student (graduate school, employed, still enrolled, etc.).
- The source of funding for the work.

Questions?

Contact James T. LaPlant
SPUR Editor-in-Chief
Assistant Vice President for Research
Valdosta State University
jlaplant@valdosta.edu