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Feature
Current Insights

Recent Research in Science Teaching and Learning

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This feature is designed to point *CBE—Life Sciences Education* readers to current articles of interest in life sciences education as well as more general and noteworthy publications in education research. URLs are provided for the abstracts or full text of articles. For articles listed as "Abstract available," full text may be accessible at the indicated URL for readers whose institutions subscribe to the corresponding journal. This themed issue focuses on recent studies on various aspects of the impact of undergraduate students' participation in internships.

1. Eagan MK, Jr., Hurtado S, Chang MJ, Garcia GA, Herrera FA, Garibay JC (2013). Making a difference in science education: the impact of undergraduate research programs. Am Educ Res J *50*, 683–713.

[Abstract available: http://aer.sagepub.com/content/50/4/683.abstract]

This study was designed to explore the relationship between participation in a structured undergraduate research program and aspirations for advanced study in a science, technology, engineering, and mathematics (STEM)-related discipline, and to address what the authors identified as methodological shortcomings of previous studies that have examined the benefit of undergraduate research experiences (UREs). These include the tendency to 1) generalize from findings from individual institutions or programs, 2) collect data based on retrospective rather than current reflections (e.g., from alumni), 3) use interpretive (descriptive) analyses rather than correlational or multivariate to compare participants and nonparticipants, 4) have the potential for selection bias (decision to participate in a URE may not be random), and 5) overstate the effects on aspirations to pursue graduate study because of the use of grade point average (GPA) cutoffs in the URE recruitment process (high-achieving students may have prior inclinations toward graduate or professional school study).

The study analyzed a national longitudinal data set derived from responses of undergraduates to two surveys administered by the Cooperative Institutional Research Program at the Higher Education Research Institute: the 2004 Freshman Survey and the 2008 College Senior Survey. The sample consisted of more than 4000 students from a range of racial and ethnic backgrounds at more than 200 participating colleges and universities. The dependent variable was intent to pursue postgraduate study, either STEM or non-STEM, and the independent variable was whether the respondent participated in a structured URE. Controls included a range of student background characteristics that have the potential to shape educational aspirations. Potential predictors such as the influence of individual dispositions; interactions with faculty, graduate students, and teaching assistants; academic major GPA; general type of career goals (working for social change vs. discovering new knowledge); student finances; and various aspects of institutional context (e.g., size, selectivity, etc.) were included in the model. The data were analyzed using statistical modeling, in part to account for selection bias.

The major finding from the analysis was that, across institutional contexts, after reducing the possible effects of self-selection bias, URE participation had a significant positive effect on undergraduate STEM majors' intent to pursue STEM-related postgraduate study (by 14–17 percentage points over nonparticipants). The fact that intent to pursue non–STEM related study was not enhanced was interpreted as an indication that the UREs were structured in a way that specifically influenced interest in pursuing STEM degrees. Additionally, the analysis indicated that Latino and black participants were more likely to report interest in postgraduate study than their white counterparts. Although the authors note that none of these students may actually follow up on their aspirations, they conclude that the findings nonetheless

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suggest the importance of the investment that federal agencies, foundations, and institutions have made in UREs toward developing and sustaining capacity in the STEM workforce.

2. Adedokun OA, Bessenbacher AB, Parder LC, Kirkham LL, Burgess WD (2013). Research skills and STEM undergraduate research students' aspirations for research careers: mediating effects of research self-efficacy. J Res Sci Teach *50*, 941–950.

[Abstract available: http://onlinelibrary.wiley.com/doi/10.1002/tea.21102/abstract]

Numerous reports show perceived benefits from undergraduate students' participation in a faculty-mentored URE, including growth in critical thinking and communication skills and ability to practice science, enhanced confidence about doing research, persistence toward graduation, and aspirations for graduate study and research careers. The authors contend that, although the published research on student gains related to participation in a URE is becoming abundant, systematic and empirical research to more deeply explore the claims made about these outcomes or the specific processes and the contexts for achieving them is much less common. The intent of this study is thus to expand the knowledge base about the relationships between URE outcomes and the processes through which they may be achieved—more specifically, by investigating the sequential interrelationships between development of research skills and research self-efficacy and students' aspirations toward research careers.

The authors hypothesized and tested a model for these interrelationships in which research careers are longer-term outcomes, and research self-efficacy beliefs and research skills are medium-term and immediate outcomes, respectively. Additionally, they hypothesized that research career aspirations would be predicted by self-efficacy beliefs and by research skills through an indirect effect on self-efficacy. The model was based on evidence from the literature, and grounded in social cognitive career theory (SCCT). Briefly, SCCT holds that career choices are influenced by beliefs that individuals hold and shape through factors such as personal accomplishments and social persuasion and through vicarious experiences of others' learning and accomplishment (Lent *et al.*, 1994).

To test the model, the authors administered a postparticipation survey to 156 students who participated in a faculty-mentored interdisciplinary STEM research program (at a large research university). Participation required a minimum GPA of 3.0. The authors tested their hypothesized model using structural equation modeling to analyze survey findings, controlling for effects of gender on research aspirations and self-efficacy beliefs and for length of time spent in the program. The analysis supported all of the direct and indirect effects that were hypothesized—research skills and research self-efficacy beliefs are important predictors of research career aspirations. The authors note, however, that the study had several limitations—data were collected on a single campus, and participants were high-achieving students who may have had high self-efficacy beliefs before URE participation. The authors conclude that, although structural equation modeling shows correlation, which does not necessarily imply causation, this study can nevertheless serve as a platform for future exploration of the application of career and other relevant theories to UREs and of how the particular contexts and processes of particular UREs shape their outcomes.

3. Taraban R, Logue E (2012). Academic factors that affect undergraduate research experiences. J Educ Psychol *104*, 499–514.

[Abstract available: http://psycnet.apa.org/journals/edu/104/2/499]

This study explored the generally accepted premise that, because authentic research experiences can be "one of the most powerful instructional tools" (National Science Foundation [NSF], 1989, p. 6), all undergraduate students should be encouraged to participate, early and often. This premise is referred to in the article as the "unconstrained" pedagogical model for undergraduate research. To examine whether a constrained model is more appropriate, the authors assessed the benefits of undergraduate research in a broad sample of students ($n = 574$) at a large research university as a function of self-reported academic behavior (including frequency or time of various types of engagement in research activities) and of demographic variables such as gender, GPA, number of college credits, and major discipline. Twenty-eight percent of the study participants were biological sciences majors, and 59% were women.

The perceived benefits of undergraduate research were assessed through administration of the Undergraduate Research Questionnaire (URQ; Taraban *et al.*, 2008), an instrument with five subscales that connect with critical aspects of the research experience. These subscales are: 1) Academic Mindset (dispositions toward self-regulated learning); 2) Research Mindset (commitment to and enthusiasm for research); 3) Research Methods (confidence in ability to design and carry out experiments); and 4) Faculty and 5) Peer Support (social and academic support provided by research mentors and peers). The authors used statistical analyses that included correlation and hierarchical regression analyses to examine associations between the URQ subscale factors and the demographic data. The analyses revealed that, overall, the strongest predictors of URQ factors were (in decreasing order) gender, GPA, research hours, college credits, and the frequency of faculty meetings; the authors also report these predictors more specifically for the five URQ subscales. To highlight a few of these results: 1) time spent on research and related activities (including laboratory course work) predicted students' enthusiasm for the research experience (Research Mindset); 2) frequency of meetings with mentors predicted Research Mindset and Methods (the more frequent, the more favorable the scale scores); 3) GPA was a significant predictor of all five URQ factors (higher GPA was favored, particularly with respect to research experiences occurring later in students' undergraduate careers); 4) gender predicted Research Mindset and Methods (favoring males); and 5) major predicted Research Mindset, Methods, and Peer Support (e.g., favoring biological sciences majors over psychology majors, who comprised 33% of the study population).

Although the authors acknowledge limitations of the study (e.g., possible incompleteness of the URQ with respect to important factors, and sampling limited to a single university), and add cautionary notes about interpretation of some of the findings, they conclude by stating that it is "not universally true that all students will benefit or will benefit equally from

research-related experiences" (p. 512). They recommend the need for closer examination of the practices needed for particular students—women, for example, or students with lower academic success—to be fully engaged in and benefit from UREs.

4. Villa EQ, Kephart K, Gates AQ, Thiry H, Hug S (2013). Affinity research groups in practice: apprenticing students in research. J Eng Educ *102*, 444–466.

[Abstract available: http://onlinelibrary.wiley.com/doi/10.1002/jee.20016/abstract]

Although considerable evidence exists that students can benefit in important ways from participation in a URE, many programs for the most part provide opportunities for students with competitive GPAs and/or high standardized test scores. This article describes and documents development of an affinity research group (ARG) model aimed at providing academic and social support structures such that UREs can be expanded to a broader range of students with the potential to participate. The ARG model design builds on the STEM literature regarding URE outcomes and draws from Lave and Wenger's (1991) situated-learning theory, particularly the concept of "legitimate peripheral participation." Briefly, according to this theory, situated learning takes place in the particular social and physical context in which the learning can be applied. Novices (apprentices) are initiated to the community of practice and gain experience and community acceptance by participating in the types of low-risk and simple (yet useful to the community) tasks that are most accessible to them.

The initial sections of the paper describe the main features of the ARG model, which explicitly targets mentoring and activities that foster development of students' research skills, disciplinary knowledge, and team skills through use of team meetings and focused workshops. To demonstrate how a team meeting would be conducted through use of probing questioning and instructional dialogues, the authors provide (for potential adopters) an example meeting transcript, with accompanying analysis and commentary, and a table that maps elements of communities of practice to their actualization in the ARG model. They then describe the qualitative research approaches used to investigate three questions on the following issues related to the longer-term impact of the model on participants: 1) how and to what extent ARG participation influenced their professional roles and identities; 2) what ARG model components were the most influential; and 3) how ARG structures and practices support apprenticeship. The study population consisted of former and current students in two ARG programs in a university in which 80% of enrolled students are Hispanic. Data sources included individual and focus-group interviews, videotapes of skills development activities, and observations of participants as they attended large group meetings and workshops, worked in their labs, and attended classes and professional conferences.

The authors report on the various themes that emerged from analysis of the data. Relating these themes back to the research questions, they describe and provide examples of specific ways in which ARG experiences were formative for participants, leading to increased commitment to and interest in their academic work and development of self-confidence in their abilities and of marketable skills, for example. For many students, ARG participation was a turning point in their academic lives and a means to establish bonds with peers that often persisted beyond graduation. The ARG model is currently being disseminated to other institutions, and a more extensive study examining the model's transferability to identify the program components essential to effective implementation in other contexts is underway.

5. Feldman A, Divoll KA, Rogan-Klyve A (2013). Becoming researchers: the participation of undergraduate and graduate students in scientific research groups. Sci Educ *97*, 218–243.

[Abstract available: http://onlinelibrary.wiley.com/doi/10.1002/sce.21051/abstract]

As is the case for many studies examining aspects of participation in mentored research experiences, this study drew on existing evidence and concepts and theories on cultural and cognitive aspects of apprenticeship and research groups as communities of practice to explore the paths by which participating undergraduate and graduate students learn how science is done. The study reports on insights drawn from a larger data set obtained through observations of research group meetings and seminars, as well as semistructured interviews of students and mentors participating in an interdisciplinary collaboration at a public research-intensive university.

The authors used standard qualitative methods to analyze the student interview data and triangulate them with data from other sources, reporting data about the frequency of occurrence of different methods of cognitive apprenticeship sorted by type of research group. They categorized research groups as being one of two types with respect to organizational structure—loosely or tightly organized. According to this classification scheme, in loosely organized groups, a lead researcher (principal investigator [PI]) serves as the center of action; students work and meet individually with the PI, with fewer interactions between peers. In tightly organized groups by contrast, lab personnel work side by side in a shared space that is the center of action and participate in group meetings on a regular basis to discuss progress, share information, critique data, and review and critique the relevant literature. The members of a more tightly organized group are likely to engage in group social interactions outside the laboratory.

The article also distills these data into case studies of three representative participants. These present models for the types of learning trajectories that individuals take as they enter research groups as novices, engage in these communities of practice, and leave as either novice researchers, skilled technicians, or knowledge generators. The authors conclude by suggesting implications of the learning trajectory model for the design of research experiences. These include the value of mentors being proactive about ways to foster their mentees' intellectual growth and of explicitly acknowledging that their students are apprentices, and that apprenticeship is the path to proficiency. The authors also suggest that, because peer mentoring can play such an important role, mentors should pay more attention to fostering positive outcomes from these peer relationships. They further suggest that more tightly organized research groups might be more beneficial for development of both methodological and intellectual proficiency. While many of the research experiences that were studied were longer term in duration, and set within the context of a degree program, some participants in the study

(undergraduates and K–12 teachers) had shorter-term experiences (typically Summer only). The authors' findings suggest that participants with shorter-term experiences gain more methodological than intellectual proficiency and that this has important implications for the teachers who participate in such programs as the NSF-sponsored Research Experiences for Teachers—they may leave lacking the experience needed to achieve the often sought after goal of supervising research apprenticeships in their K–12 schools.

I invite readers to suggest current themes or articles of interest in life sciences education, as well as influential papers published in the more distant past or in the broader field of education research, to be featured in *Current Insights*. Please send any suggestions to Deborah Allen (deallen@udel.edu).

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