

URSSA: Evaluating Student Gains from Undergraduate Research in the Sciences

For eight years, our research group has been investigating the outcomes of undergraduate research (UR) experiences in the sciences for students, their advisors, their departments and their institutions. Based on our and other recent research on UR, we have developed a web-based survey we call Undergraduate Research Student Self-Assessment (URSSA). The goal of URSSA is to enable departments and programs to gather information about what students do or do not gain from participating in UR in the sciences, and about what activities contribute to those gains.

Background to URSSA

Our group, Ethnography & Evaluation Research, conducted a large qualitative study addressing fundamental questions about the benefits (and costs) of undergraduate engagement in faculty-mentored, authentic research undertaken outside of class work, about which the existing literature offered few findings and many untested hypotheses (for a review of this literature see Seymour, Hunter, Laursen, DeAntoni, 2004). Longitudinal and comparative, this study explored:

- what students identify as the benefits of UR—both following the experience, and in the longer term (particularly career outcomes);
- what gains faculty advisors observe in their student researchers and how their view of gains converges with or diverges from those of their students;
- the benefits and costs to faculty of their engagement in UR;
- what, if anything, is lost by students who do not participate in UR; and
- the processes by which gains to students are generated.

We chose as our study sites four liberal arts colleges with a strong history of UR because findings would represent the “best case.” All four offer UR in three core sciences—physics, chemistry, and biology—with additional programs in (at different campuses) computer science, engineering, biochemistry, mathematics, and psychology. Undergraduate research in these institutions followed an apprenticeship model, where faculty worked closely with students throughout the summer—train-

ing, guiding, and mentoring them—on authentic research projects for which outcomes and answers were unknown.

We conducted multiple rounds of interviews with a cohort of students engaged in UR and with a comparison cohort who did not do UR. The faculty advisors working with the student cohort were interviewed, as well as a number of administrators with long experience of UR programs at their schools. A comparison group of faculty who were taking “time out,” or who no longer conducted UR, was also interviewed. The total of 367 interviews produced more than 13,000 pages of text data. Following a qualitative research method, we conducted a content analysis on all the interview data. From this analysis we were able to identify the range, type and relative weighting of gains from UR experience that students reported (for complete details on our research method and design see Seymour, *et al*, 2004; Hunter, Laursen, & Seymour, 2007; 2008).

We found that the benefits students described fit six conceptual categories: personal/professional gains, gains in thinking and working like a scientist, gains in skills, demonstrating norms of professional practice and understanding how scientists practice their profession (the “becoming a scientist” category), gains in career clarification, and enhanced career preparation (Hunter, *et al*, 2007; 2008). In further analyses, we found strong congruence across the student, faculty and alumni data sets, showing the robust nature of the categories.

In updating our literature review for our forthcoming book, we did a careful analysis of the gains reported in other recent research and evaluation studies of UR. In comparing findings, we also found strong convergence as to the types of benefits: all gains reported by other studies sorted into the six benefits categories identified in our research. Findings from this study and others thus provide broadly documented empirical evidence of the types of gains that derive from learning research hands-on and the role of UR experiences in encouraging student researchers’ intellectual, personal, and professional growth. Having comprehensively identified the range and type of gains to students from UR experience across multiple studies, we have designed URSSA to assess the many benefits reported.

Development and Validation of URSSA

URSSA has been methodically developed and is grounded in the research on the benefits to students of undergraduate research experience. We began by examining the empirical results to develop the survey categories and items. We piloted the draft survey in a round of “think aloud” interviews with four focus groups (each with four or five UR students) to capture the range and content of benefits reported, discuss and refine the wording of questions, and organize items in a coherent structure. Importantly, we designed URSSA’s survey items and open-ended questions to focus on students’ learning gains as program outcomes. That is, modeled upon the Student Assessment of their Learning Gains (SALG) instrument, URSSA gathers program evaluation data from students to assess what they *learn* rather than whether they liked their experience (see <http://www.salgsite.org>).

We shared these early versions of the surveys with other researchers studying UR and with directors of UR programs at research universities, master’s-granting universities, and primarily undergraduate institutions to gather their feedback and to determine if we missed any items needed for program evaluation. Following revisions based on professional collegial input, we tested URSSA in a second round of “think aloud” interviews with another four focus groups (each with four or five UR students) to ensure that the intended meaning of the survey items was easily understood. Students were asked to fill out the survey (on paper, at this stage). Then, going through the survey, section by section, we asked students if any of the survey items were unclear, confusing or seemed redundant. We queried students as to whether the survey had missed any benefit that they had gained and asked them to comment on the length, completeness and coherence of the survey. Again, we revised the survey based on this feedback.

Most items are multiple choice or numerical ratings, with a few open-ended response items. For the gains items, ratings are on a four-point scale, from 1 = no gain to 4 = a great gain (and NA = not applicable). Likert-type items were developed to reflect degree of satisfaction with various aspects of the UR experience. Respondents rate these on a 4-point scale, from 1 = very dissatisfied to 4 = very satisfied. Finally, the helpfulness of program activities to students’ learning is rated on a 4-point scale, from 1 = not at all to 4 = a great deal. A few open-ended questions address the quality of the experience, probe for par-

ticular types of gains, and seek advice for the program. URSSA takes approximately 10-15 minutes to complete.

This past summer, we conducted a nationwide pilot test to check reliability and validity of survey items across a range of formal and informal research programs in a variety of campus settings. We analyzed data for over 500 students who participated in UR at 22 institutions, including research universities, master’s-granting universities, and primarily undergraduate institutions. Undergraduate research programs at these institutions varied in size. Because the survey was sent to students from their home UR program, we could not determine a response rate, but the numbers of students responding per institution varied from 3 to 93, with most between 19 and 51. We shared each institution’s student survey results with the respective program directors for their own evaluation purposes.

Through Confirmatory Factor Analysis we compared how student responses fit the hypothesized structure of the survey and found that the data met accepted standards for model fit. We also tested survey items to learn if they functioned as anticipated; some survey items were removed from the survey or changed after not meeting criteria for acceptable item functioning. After revision, we will conduct final “think aloud” interviews with student focus groups and make any additional necessary changes. Our goal is to have URSSA up and running on the SALG website by summer 2009.

Measuring Student Gains with URSSA

The online instrument can be used for both summative and formative evaluation. For summative evaluation, URSSA provides a means to gather evidence over time about the success of the program to be shared with institutions, funders, and other stakeholders, while formative feedback is used to adjust the program for the future. For UR programs that currently use other surveys, URSSA can provide a source of comparative data.

A set of core items is fixed and cannot be changed. These measure student gains from UR across the six benefits categories and probe the general processes by which these are achieved. For summative evaluation, measurement of core benefits items provides evidence against an external standard: the gains documented in the literature. Thus URSSA is designed to measure students’:

- personal/professional gains, such as gains in confidence and establishing collegial relationships with faculty and peers;
- intellectual gains, including the application of their knowledge and critical thinking skills to research work, as well as in extending their knowledge and understanding of connections among the sciences;
- gains in professional socialization, such as changes in students' attitudes and behaviors that indicate adoption of professional norms;
- gains in various skills (communication skills, technical skills, computer skills, etc.);
- enhanced preparation for graduate school and the workplace; and
- gains in career clarification, confirmation and refinement.

Survey items include some designed to assess different levels of intellectual gain, such as gains in learning about the process of science and understanding how research is done (reported most commonly by students). Items also query higher-order intellectual gains, namely, in understanding how to pose and investigate a research question and in understanding how scientific knowledge is constructed (both reported less commonly by students). Although active participation in UR offers the potential for students to move through a sequence of intellectual gains—from application to design to abstraction—research findings indicate that this process is neither easy nor guaranteed, and very likely requires students' sustained, long-term involvement.

Our research has highlighted the role of UR in socializing students to the profession of science research, which, to date, has not been extensively documented in the literature. URSSA survey items probe changes in students' attitudes and behaviors that reflect characteristics seen as requisite to the profession and query whether and how UR affects their understanding of science as a profession and of the norms that guide professional practice. These types of gains indicate students' growth as young professionals and point to the more subtle, affective benefits of UR experience.

Other survey items aim to determine the impacts of UR experience on students' choice of career pathway: how it influenced decisions for or against graduate school, informed their view of research as a profession, or enabled them to test their

interests and temperament against the realities of day-to-day research work and to assess whether a career in science research “is right for me.”

We have used URSSA in evaluations for UR programs run by the Biological Sciences Initiative (BSI) and the National Institutes of Health (NIH) Scholars program at the University of Colorado, Boulder, and for the Louisiana Science, Technology, Engineering and Mathematics (LA-STEM) Research Scholars program at Louisiana State University. Use of the URSSA survey is proving useful in detecting differences and issues of importance. For example, Thiry's (2008) report for BSI and the NIH Scholars program shows that older and more experienced students report higher gains in professional socialization, while novice researchers report greater gains in “thinking and working like a scientist.” For the LA-STEM program, which aims to improve student retention and encourage science career pathways, URSSA showed the efficacy of particular program elements, such as program staff support and a strong peer community, in achieving program objectives (Thiry, Hunter, 2008).

Advantages of URSSA

URSSA will have a good deal of flexibility to address different institutional contexts and a variety of program types and thus will be useful for gathering formative feedback about the program. By selecting from a menu of optional items, program directors or departmental UR administrators will be able to tailor the survey to assess the contributions of specific program elements (i.e., career seminars, field trips, writing workshops, etc.). In addition to collecting demographic data, URSSA will allow departments and program directors to track other issues of importance, such as how students found out about UR at their institution, their reasons for undertaking UR, or whether the availability of UR opportunities was an important factor in students' choice to attend the institution. We are unaware of any other UR instrument that allows users this degree of flexibility.

Once URSSA is fully implemented, it will be available at no cost to UR program directors and departmental UR administrators. URSSA users will be able to view numeric results as raw data, summary statistics, cross-tabs, and graphs. They will also be able to download a report with all questions and data in a preformatted Excel report. We are also working to add a qualitative data analysis function to the site. This function will enable

users to qualitatively and quantitatively analyze the content of students' comments in response to open-ended questions, allowing UR administrators to take full advantage of the data. This capacity may be of particular value to URSSA users because, as we have found, UR students are quite able to give insightful feedback on their summer research experiences.

Limitations of URSSA

Lopatto (2007) argues that student learning and experience may be most directly assessed through self-report. Certainly our qualitative study of UR indicates that students have substantial self-awareness of their own growth and of the processes through which it accrues. Thus, student self-report is one important tool in the evaluation toolkit for any UR effort. In our experience with URSSA, we find that students can reliably assess their own gains in areas already familiar to them—for example, gains in content knowledge or laboratory skills—and personal growth. However, student self-assessment in new domains, such as understanding the nature of science, is less useful in distinguishing degrees of gain. As novice researchers, students are simply not aware of how much more there may be to learn. We continue to refine our survey to include items that capture these gains appropriately. In future work, we hope to develop tools complementary to URSSA that are useful for gathering assessment data from advisors and other informed sources.

The question also arises as to whether URSSA is applicable in measuring outcomes of UR in fields outside the sciences. Because URSSA is grounded in the research on UR in the sciences, it is neither written for nor validated for use in non-STEM fields, where the traditions, practices and outcomes of UR are less well established or characterized.

To protect the anonymity of student answers, URSSA is used only for student groups of 10 or more who participate in science research through their departments or in organized programs. It is not suitable for individual laboratories or for the assessment of research mentors. However, the questions offer topics that individual advisors can discuss with their students to gather feedback for their own use.

For more information, and to review a working, preliminary version of URSSA online, see:

http://www.surveymonkey.com/s.aspx?sm=vBY1ie_2f4fE_2bdZIX111hFQ_3d_3d

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