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Pivoting Toward the Future: Fifty Years of Summer Research Fellowship Success Catalyzes Institutional Change

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Pivoting Toward the Future:
Fifty Years of Summer Research Fellowship Success Catalyzes Institutional Change

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Abstract

For 50 years, Smith College's Summer Research Fellowship (SURF) has provided undergraduate women scientists the opportunity for an immersive experience to conduct independent research under the mentorship of science faculty and staff. This article highlights summative assessment data on SURF program outcomes as well as the institutional planning and responses that followed from careful consideration of SURF's success and challenges. SURF participation was associated with a full range of student benefits, including a higher overall college grade-point average, greater advanced research participation, and increased likelihood of completing an advanced degree. Evidence of these powerful and lasting student impacts associated with the SURF program was integral to divisional strategic planning within the sciences and helped propel curricular innovation broadly, creating faculty and institutional investments in a broad range of cutting-edge pedagogical approaches that are student-centered and inquiry-driven.

Keywords: *institutional change, scientific research, strategic planning, summer research programs, undergraduate research, women in science*

In science, technology, engineering, and mathematics (STEM), there have been concerted calls for institutional investments in undergraduate inquiry-based learning opportunities as a means of expanding persistence and engagement to meet the needs of an increasing knowledge-based economy (President's Council of Advisers on Science and Technology 2012). Undergraduate research experiences, such as summer apprenticeships, are well regarded as an effective, high-impact educational practice, based on their robust learning outcomes for a wide variety of students (Association of American Colleges and Universities 2011; Linn et al. 2015). According to the extant literature, advantages of summer apprentice-based research programs are wide ranging, including benefits related to students' self-reported learning gains, intentions to continue in science, graduate school aspirations, and academic trajectories (Bauer and Bennett 2003; Lopatto 2004; Lopatto 2007; Seymour et al. 2004).

Even proponents of substantive research opportunities for undergraduates, however, note the challenges inherent to the model of providing apprentice-style educational experiences in a broad systematic fashion (Awong-Taylor et al. 2016). These hurdles relate to program expense, faculty time, and the dedicated effort required of both students and their mentors, among others (Linn et al. 2015). Difficulties with scaling up and sustaining effective programs and pedagogies is not unique to undergraduate research experiences. Indeed, many science education researchers have shifted to elucidating how to foster institutional change informed by empirically validated educational approaches (Henderson, Beach, and Finkelstein 2011). This kind of change can be difficult to enact but Henderson et al. (2011) note that effective approaches involve longer term interventions that reflect and/or address local values and beliefs and are compatible with the institution's broader culture.

This article describes how the Summer Research Fellowship (SURF) program's success helped to reflect and propel institutional change. Undergraduate research is a core practice of scientific education at Smith College,

and SURF is one of the college's most long-standing and visible programs embodying that practice. Nonetheless, the program's challenges, common to summer apprenticeships, became increasingly problematic over time because of its growth. This article describes strategies that strengthened the SURF program itself while ultimately fostering additional pedagogical innovation. It highlights the summative assessment data that helped to propel these institutional changes and describes the effective strategies (Henderson et al. 2011) critical to the process.

A Half Century of Summer Research Fellowships

Smith College, one of the largest undergraduate institutions for women in the nation, enrolls approximately 2,500 students each year. Celebrating its 50th year, Smith College's Summer Research Fellowship (SURF) program has provided about 3,500 undergraduate students with the opportunity for an immersive experience (typically 30 to 40 hours per week for 8 to 10 weeks of summer) to conduct research under the mentorship of science faculty and staff. Over the years, SURF has grown from an inaugural cohort of 12 undergraduates to approximately 150 students participating each year (from 2011–2017; see Figure 1). Dozens of faculty mentor-advisers drawn from across 13 science, mathematics, and engineering departments and programs provide SURF students with opportunities to collaborate on authentic research problems, often those that are germane to Smith faculty's areas of programmatic research and are student directed.

Since 2005, Smith's SURF program has grown by approximately 50 percent, fueled by faculty recognition of the power this kind of learning has on student academic trajectories as well as burgeoning student demand for meaningful research opportunities. With this growth, tensions began to emerge. As SURF became increasingly popular and generated a broad view that hands-on opportunities for research provided a powerful and lasting impact on students, demand for the program began to outstrip its designated institutional resources (only student stipends were supported). As noted by others (Linn et al. 2015), the costs of these kinds of undergraduate research experiences require significant institutional investment, placing an even greater imperative on careful analysis of outcomes. In the past decade, faculty have devoted significant efforts to evaluating the SURF program, seeking to determine whether the program provided empirical evidence of its benefits—especially over the long term—to participating students.

Program Evaluation

The broad research literature finds consistent and converging evidence of the student benefits associated with summer research participation, although most studies focus on student self-reporting, usually near term (Fechheimer, Webber, and Kleiber 2011; Linn et al. 2015). Similar data from this research echoes these findings. Building on the established literature, the authors report on the outcomes data that were most powerful in positioning the SURF program for its long-term success: objective data on academic performance and trajectory as well as postgraduate education and career outcomes for SURF participants versus their peers. Given concerns about the possibility of SURF selection bias, data that control for incoming student characteristics are included in these comparisons.

Overall College Grade-Point Average

Quantitatively analyzing academic record data for more than 2,000 students who entered Smith in the years 2007 to 2010, Brodigan (2012) examined whether SURF

FIGURE 1. Number of Students Participating in Summer Research Fellowship Program, 1967–2017

FIGURE 2. Participation in Advanced Research Activities by SURF and Non-SURF Science Majors, 2007–2016
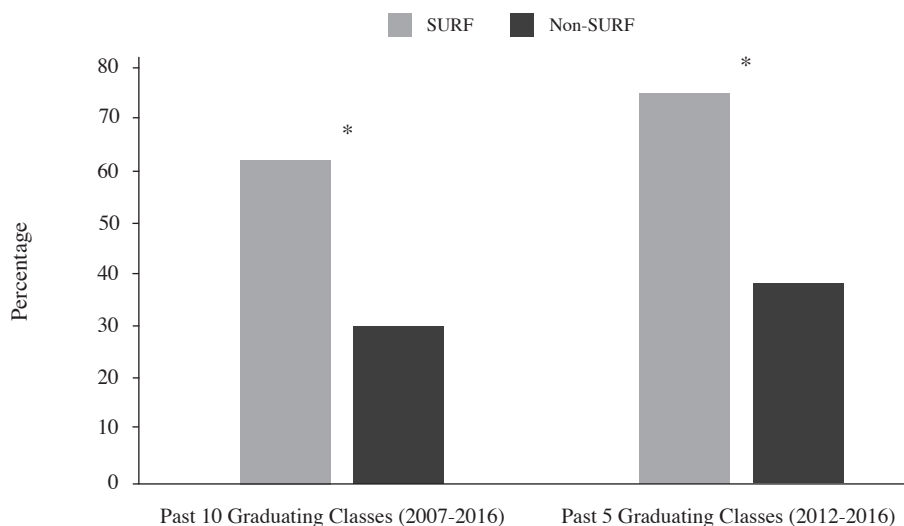
Note: Past 10 graduating classes range from 2007 to 2016 (SURF: N = 852; non-SURF: N = 1580). Past 5 graduating classes range from 2012–2016 (SURF: N = 488; non-SURF: N = 813). For SURF participants, advanced research must follow summer research experience to count. Asterisks note significant differences between SURF and non-SURF participants (two-sided proportion z-tests, p-value < 0.05, $|z|$ > 1.96).

program participation affected students' overall college GPA. Using multivariate ordinary least squares regression analyses, he examined the relationship between students' SURF program participation and actual overall percentile GPA rank relative to predicted GPA. In this analysis, Brodigan controlled for variables available at the time of admission (including SAT scores, demographic characteristics, and admission reader rating determined by holistic assessment) as well as participation in other research and science pipeline programs available to Smith students.

The results indicated that SURF participation positively related to student academic performance, providing benefit beyond what might be expected when measuring incoming academic characteristics alone. Students who participated in SURF had cumulative grade-point averages that significantly exceeded expectations based on their incoming SAT scores (β = 6.89; p < 0.01) and reader ratings assigned at the time of application (β = 4.69; p < 0.05). This was true even after accounting for effects of other research and science pipeline programs. These statistically significant gains represented seven percentile GPA rank points relative to expectations of predicted GPA based on combined math and verbal SAT scores (or five points when based on admission reader-rating scores).

Advanced Research Participation

In a separate set of transcript analyses of student academic records, it was determined whether SURF participants were more likely than their non-SURF peers to engage in advanced research participation (defined as credit-bearing faculty-mentored research opportunities available through honors or independent research in the third or fourth year; for SURF students, this research had to occur after they participated in the SURF program). Results indicated that SURF participants were significantly more likely to engage in advanced research experiences than non-SURF science majors (75 percent vs. 39 percent for 2012–2016; see Figure 2).

Graduate School and Career Trajectories

To examine the trajectories of SURF program participants following graduation, Lopatto and Trosset (2008) examined responses of almost 800 Smith alumnae (who were science majors and graduated between 1974 and 2007, reflecting a 62.7 percent response rate) to a survey about vocational and educational pathways. Of this group, 413 were former summer researchers; they were compared to peers (N = 354) who did not engage in summer research.

When former student researchers were asked about activities in their current vocation, they reported significantly greater involvement with research, science, and environmental study. Non-SURF alums were more likely to opt for business and social service opportunities (see Figure 3). There were no significant differences between the two groups related to vocations in education or health care, or to raising a family.

FIGURE 3. Activities Involved in Current Vocation for SURF and Non-SURF Participants for Alumnae Sample, 1974–2004

SURF (N = 413)   Non-SURF (N = 354)
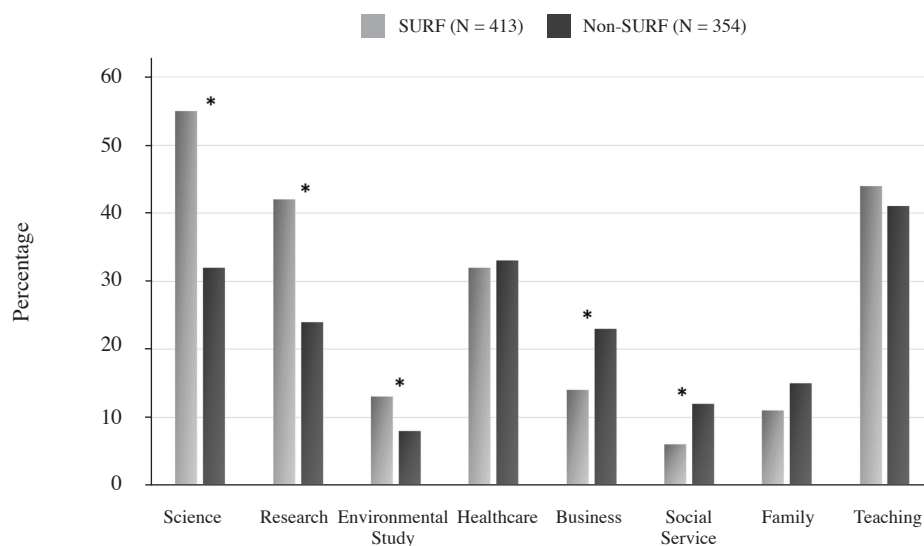
Note: Respondents may choose more than one category. Asterisks note significant differences between SURF and non-SURF participants (Pearson's Chi-Square test, *p*-value < 0.05 with Bonferroni correction, $\chi^2 > 3.841$, *df* = 1).

In addition, alumnae reported on their activities at one to three points in time—graduation, five years after graduation, and 10 years beyond graduation—depending on how long it had been since they graduated. Seven categories were coded for each period: graduate/professional schools, science jobs, other technical jobs (quantitative analysis or computer programming), nonscience jobs, teaching science, searching (planning for the next life stage or looking for employment/applying to school), and taking time off. Former summer research students were significantly more likely to report involvement with science jobs at each time point.

Summer research alumnae taking this survey also reported going on to complete more science doctoral degrees than science peers who did not engage in summer research. Non-SURF students were more likely to earn professional master's degrees or no advanced credential (see Figure 4). Further analysis of these same data found that SURF students were about two times more likely to complete an advanced degree following graduation from Smith than non-SURF students (Hakim et al. 2012), even when controlling for propensity scores based on SAT total score and/or admission reader rating as well as incoming student characteristics (such as self-identified ethnicity and graduation year; see Table 1).

Institutional Change

The series of program evaluations described here provided grounding evidence that the SURF program prepares students for today's innovation economy, producing outcomes that extend beyond the undergraduate years and foster women's engagement in science. Consistent with the broader literature (Bauer and Bennett 2003; Lopatto 2004; Lopatto 2007; Seymour et al. 2004), SURF participation was related to academic, career, and advanced degree outcomes that aligned well with the institution's educational goals, including participation in advanced research, better overall GPAs (Fechheimer et al. 2011), and graduate degree completion (Junge et al. 2010), even after controlling for a variety of incoming student characteristics for the latter two variables.

Strategic Planning

The results of these program evaluations tangibly articulated the value of SURF's educational role in Smith's sciences division at a time when a number of important shifts happened at the institution. First, there was change in leadership of the division. In the sciences, the college replaced its older model that exclusively relied on full-time administrative staff and inaugurated a model that partnered a full-time staff person who served as administrative director with a half-time (rotating) faculty member who served as faculty director of the sciences. This pair was charged with operational oversight as well as curricular and long-range planning in the Clark Science Center. The Science Center directors engaged the college's long-standing Science Planning Committee, a deliberative and advisory body of faculty with one representative of each department in the sciences division, often its chair.

The future of the SURF program was an immediate shared agenda item for the directors and the committee, given

FIGURE 4. Advanced Degree Type for SURF and Non-SURF Participants, 1974–2004
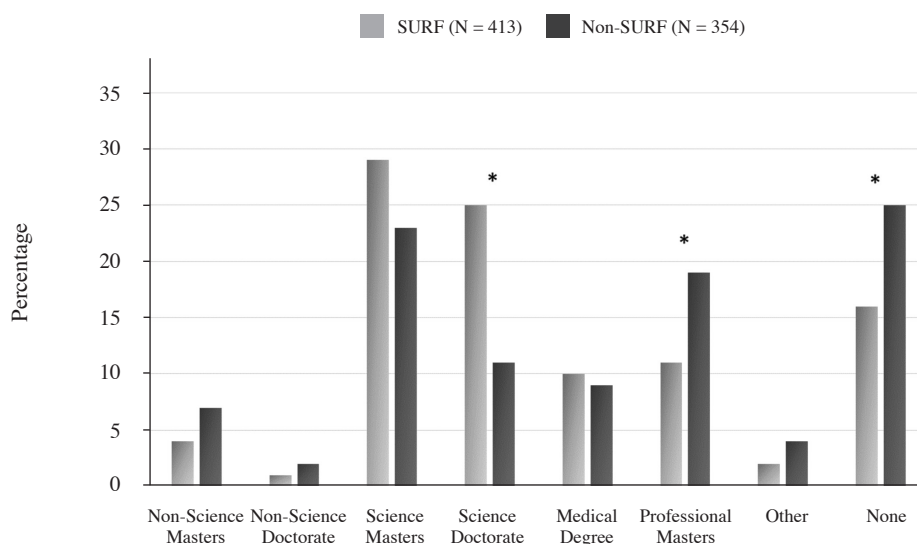
Note: Respondents may have multiple degrees, and percentages are based on total number of degrees. Asterisks note significant differences found between SURF and non-SURF participants (two-sided two proportion *z*-tests, *p*-value < 0.05 with Bonferroni correction, |*z*| > 2.779, *df* = 948).

TABLE 1. Odds Ratios Using Multiple Logistic Regression Modeling of Relationship of SURF Participation to Graduate Degree Outcome, Controlling for Propensity Score

	SAT only in propensity score OR (95% CI)	Reader rating only in propensity score OR (95% CI)	Both SAT and reader rating in propensity score OR (95% CI)
Participation in SURF	1.9 (1.2–2.9) N = 384	2.1 (1.4–3.2) N = 269	1.9 (1.2–3.0) N = 247

Note: From Hakim et al. (2012). To mitigate possible biases introduced by students self-selecting into the SURF program, each student was given a propensity score that estimated the probability of getting an advanced degree, based on individual student variables (including ethnicity, graduation year, incoming SAT scores, and/or admission reader rating score at the time of application). These students were then matched with non-SURF participants who had similar propensity scores. Odds ratios (OR) and confidence intervals (CI) were then calculated using a multiple logistic regression model in which the outcome variable was the presence (any graduate degree) versus absence (bachelor's or below) of graduate degree.

the program's growth and accompanying fiscal demands, including the anticipated end of grant-related SURF funding. Science faculty and the Science Center directors began a series of conversations, first within the sciences and later with college leadership, about the SURF program's long-term viability. Simultaneously, the new leadership in science administration launched, for the first time, strategic planning for the division in order to create a forward-thinking, collaborative agenda with faculty and staff. The process of the strategic planning was informed by broad participation, best practices pedagogical literature, and institutional data and values. This was an emergent process that developed

a shared vision of prospective strategic directions and their underlying principles (Henderson et al. 2011). The SURF program was an integral part of this conversation due to its historical successes as well as its current financial needs. In the preceding year and during this process, SURF program evaluation results were reported to division faculty through a variety of venues, including Sigma Xi (a scientific research society) as well as Science Planning Committee meetings.

Science faculty were not at all surprised that program evaluations revealed tangible impacts of the SURF program on their students' lives, both at Smith and beyond.

Conversations revealed that faculty and staff perspectives on the SURF program triangulated well with student reports and outcomes assessed by these independent evaluations. The explosive growth in SURF numbers over the years happened in large part because of faculty and student recognition of the power and importance of these kinds of authentic research experiences. In virtually every conversation about SURF's value and future at the college, science faculty reported that research collaborations such as these were often the most rewarding kind of teaching they did. Yet, despite this widely held view in the sciences division as well as ongoing faculty advocacy for further college investment, there was concern about the long-term sustainability of the program given that the institution's financial commitment to SURF had remained stable over time. Nonetheless, the strategic planning process revealed time and time again that science faculty wanted to engage with the question of how authentic research experiences, like those of the SURF program, could be positioned at the center of the division's educational mission.

After nine months, a new strategic plan was adopted that helped to inform subsequent strategic budget priorities in the sciences as well as institutional grant-planning efforts. Consistent with what was learned from the SURF evaluations as well as subsequent discussions of this and other successful research mentorship programs (e.g., Katz et al. 2017), the final strategic plan identified four directions for consolidated efforts. Overall, the plan emphasized the importance of ensuring access to high-impact practices that would foster student knowledge and skills in relation to real world problems while fortifying their agency and scientific identity. One of the plans' strategic directions heavily emphasized the importance of developing students' expertise through research opportunities. Overall, the sciences' plan built on the division's success, including SURF, and imagined a future in which experiences like SURF would be woven throughout departmental curricula and thus broadly available to students.

A number of benefits accrued as a result of the sciences division's empirically grounded strategic planning process. Not long after completing the process, the college launched a self-study and college-wide strategic planning process. When the administration called for strategic planning proposals from faculty, staff, and students, the Science Planning Committee had just completed its own strategic planning process and had a galvanized sense of the power and importance of student-faculty research collaborations in the lives of students. Thus, the Science Center directors and the Science Planning Committee collaborated to organize and submit a series of interconnected proposals to the college-wide committee overseeing the strategic planning process. These proposals highlighted the importance of future college investment in student-centered and research-focused learning experiences. Ultimately, the sciences division's strategic directions were well represented in the college's 2016 strategic plan (Smith College 2016). One of the five strategic directions endorsed in the college's plan described "expanded experiential and applied opportunities" (13–14) with the goal of strengthening access to research, including an expansion of SURF.

There are two other important points about the college's strategic plan that were quite relevant to SURF's future. One was that SURF, and programs like it, were integrated into the revised mission of the college. The plan's mission statement articulated the importance of linking "the power of the liberal arts to excellence in research and scholarship, thereby developing engaged global citizens and leaders to address society's challenges" (Smith College 2016, 4). Second, the college's plan helped to set the agenda for central planning, resource allocation, and development priorities in the coming years. The presence of experiential learning and SURF-related research experiences in the plan provided promise for the institution's continued commitment to the program, the faculty who advocate for it, and the students who benefit from it.

Challenges of Implementing Vision

Even with widespread science faculty support, compelling data of the SURF program's success, and SURF's inclusion in the college's strategic plan, conundrums remained about three critical aspects of the program: problems related to cost, scale, and access. Both science faculty and college administration raised questions about the ability of the institution to sustain continued growth of the program over time given its trajectory. As noted elsewhere, apprentice-based program costs are substantial; Smith's is no exception. In addition, the limited ability of faculty to take on the growing number of SURF participants was a matter of local concern. Finally, these many conversations about SURF led the division to grapple with what Awong-Taylor et al. (2016) refer to as the "elephant in the room": the historical lack of inclusivity in these kinds of programs.

As staff worked to tackle these challenges, it was realized that SURF's apprentice-based model was not going to achieve the long-term goal of making authentic research experiences available to all students. Although the participants in SURF had become increasingly diverse over the years in a variety of ways (class year, first-generation college student status, and racial and ethnic composition; see Lamb et al. 2015), scaling up the program to include every science student would require prohibitive fiscal costs and faculty time. There was not enough faculty availability to ensure full inclusivity. Many faculty members were feeling the strain of mentoring thriving research labs single-handedly throughout the calendar year. Conversations with students about SURF also revealed that this opportunity was a privilege not all students could afford. Some students experienced challenges or could not be away

from home during the summer months due to family obligations, housing and meal expenses, or the need to earn a summer salary to contribute to tuition costs.

To address program expense, efforts were made to make the needs and value of the SURF program more visible to and better understood by college leaders who managed strategic budget and capital planning processes. As recently as 2014, only a little over 50 percent of the SURF program funding came from regularized institutional budget sources. "Softer" funding provided the balance: end-dated institutional grants, student research stipends built into external faculty grants, and discretionary pockets of external funding. Even creatively cobbling together all of these sources of funding, student demand for SURF was regularly outstripping supply by 10 to 20 percent, resulting in about 15 to 20 students each year who had a willing supervisor but were unable to secure a stipend. During this struggle to fund all valid student requests, an institutional grant from the Howard Hughes Medical Institute (HHMI) that covered more than 20 SURF stipends per year was about to expire, creating additional impetus to collate findings from program evaluations and articulate a strategy for future funding.

The goal was to secure funds that would meet the needs that were emerging from students who had secured faculty sponsorship. To that end, the work done by science faculty through its own strategic planning and evaluation of SURF helped to provide a convincing set of arguments that the institution should meet these needs. As the college's strategic plan was being developed, the administration made a significant new investment in the Science Center's operating budget to support SURF on an ongoing basis after the HHMI grant expired. In 2017, Smith added more than 20 SURF stipends as well as a new summer research supplies fund to the operating budget. The combination of faculty advocacy and objective data about academic and postgraduate outcomes of SURF students created a compelling case for this significant investment, aligning the division's goals with institutional strategic budget decisions.

Ongoing conversations about the success and challenges of SURF and other research programs during the strategic planning process helped faculty invest energy in thinking creatively about how to tackle the significant problems of access and scale. DiBartolo and colleagues (2016, 1) called undergraduate research experiences a principle of inclusivity in science education. SURF's established successes raised the question of how to provide the broadest access to this kind of opportunity rather than serving only a subset of students. Many faculty members began to play with the notion of blurring the lines between their classrooms and their research labs by developing more student-centered and inquiry-driven pedagogical approaches as a way of efficiently broadening student access to faculty

collaborations. In the years immediately preceding the sciences division's strategic planning, the division invested significant effort to developing new course-based research experiences funded through a HHMI grant (2012–2016). At the same time, faculty in the sciences developed a series of programs that focused on increasing the access and success of underrepresented science students (Katz et al. 2017). Energized by these pilot course revisions and propelled by the division's investments in inclusion, faculty came together to collaborate, problem solve, and support efforts to improve access and expansion of research opportunities for all students.

As strategic planning was taking place, science faculty were increasingly embedding research-rich practices throughout departmental curricula, and doing so at the earliest stages of study with their students, all while exploring this and other ways to make undergraduate research more inclusive. With the sponsorship of the Sherrerd Center for Teaching and Learning, Smith's faculty director of the sciences led a faculty learning community focused on expanding course-based research experiences in the sciences. This group met for monthly lunch meetings over the course of two academic years. Through that venue, a community of teachers collaborated to expand developmentally appropriate and scaffolded course-based research experiences. Over the period of the HHMI grant, the number of courses offering research experiences increased by about 15. Another outcome of these productive conversations included creative institutional grant proposals that sought funding to bring innovative ideas to fruition and expand meaningful research practices and opportunities. One of these efforts resulted in a new grant award. In spring 2017, Smith was chosen as one of 12 institutions nationwide to participate in a CUR Transformations Project grant to develop integrated and research-infused curricula in two science departments. There is a commitment to considering collaboratively how best to connect course-based research experiences and provide clear and scaffolded pathways that lead to a cohesive program of research opportunities for students within any one department.

Summary

Program evaluation data paired with collaborative divisional strategic planning helped to articulate a vision for the future that solidified SURF's standing and imagined innovative ways to achieve its promise more inclusively in the future. Advocacy for the resources necessary to maintain the excellence of the SURF program continues. Collaborative approaches to the challenges of program cost, access, and scale, have expanded success in propelling faculty and institutional investment in authentic research opportunities for students. The continuing challenges are ones shared by faculty and institutions striving to move curricula toward fully engaging best practices, including

the need for coordinated and full-scale faculty buy-in, fuller alignment of faculty incentive and promotion structures with these kinds of mentored research experiences, and disciplinary agreement (American Association for the Advancement of Science 2010) about how to balance teaching content and competencies with research experiences (Awong-Taylor et al. 2016).

This work is ongoing and continues to build on the shared vision and community building that has propelled it thus far. As noted by Henderson and colleagues (2011), effective change strategies in STEM education require sustained efforts and long-term investment to alter environment and structures within complex systems, like colleges and universities. In many ways, the process of collaborative strategic planning helped to galvanize local vision about the power and value of student research opportunities and then align that vision with broader college goals.

Rather than becoming stale over time, SURF—one of the college's oldest programs—helped inspire creative thinking about the future. The sciences division will continue to build on SURF's program successes and seek to ensure better preparation of Smith students for the new knowledge economy through stable support of SURF as well as expanded investment in research-infused curricula. It is hoped that this article shows how program evaluation, grounded in thoughtful planning informed by past successes, can help institutions pivot toward the future. Looking forward to the next 50 years, the science faculty at Smith pursue student-research opportunities as advocates of Smith's educational mission to link the power of scholarship and research to engaged citizenry.

Acknowledgments

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