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Encouraging and Sustaining a Culture of Student-Centered Research at a Predominantly Undergraduate Institution

The Center for Undergraduate Research and Education in Science, Technology, Engineering and Mathematics (CURE-STEM) at the University of Central Oklahoma is designed to encourage faculty development and student learning through undergraduate research at our publicly funded, predominantly undergraduate institution. It incorporates best practices from a now-burgeoning literature on undergraduate research and has yielded a positive fiscal return on investment in faculty members who support student-centered research activities. The model should prove beneficial for those wishing to develop a similar center on their own campuses. In the following discussion we particularly focus on: 1) the significance of aligning an undergraduate research center's goals with the academic and/or university mission in acquiring administrative support and building fiscal resources; 2) the incorporation of best practices from the literature and from feedback at conferences where these issues are discussed; 3) return on investment and fiscal sustainability; and 4) the direct and ancillary effects associated with this model.

Background of the Model

During the last two decades an increasingly evident change has occurred among institutions of higher education in the United States, a shift from teaching-centered practices toward a learning-centered paradigm for undergraduate education (Barr and Tagg 1995). This transition has been particularly relevant to institutions (both public and private) that have emphasized undergraduate education and that are now known as predominantly (or primarily) undergraduate institutions (PUIs). The University of Central Oklahoma (UCO) is the oldest institution of higher learning in the state of Oklahoma with roots as a Territorial Normal School. Consistent with its tradition as Oklahoma's Teachers College and a more recent trend toward high-impact educational practices (Kuh 2008), an initiative called Transformative Learning was established on the UCO campus, along with several means of facilitating learning practices (Barthell *et al.* 2010). The initiative required institution of a faculty-development model that supported student-centered learning in the university's College of Mathematics and Science (Barthell 2012).

One of the emerging, and sometimes controversial, components of student-centered education is undergraduate research. Kuh (2008) specifically identifies this pursuit as among his ten high-impact educational practices. However, the ability of faculty members to establish themselves as successful practitioners of undergraduate research requires a cultural transition that can cause unease at many PUIs (Malachowski 2006). Although there is little doubt about the effectiveness of undergraduate research in helping to retain students in the undergraduate curriculum (Crowe and Brakke 2008), the way to encourage faculty members to embrace the practice, given the high teaching and service loads common to faculty members at PUIs, remains a major topic of discussion across the country.

In 2008, we established the Center for Undergraduate Research and Education in Science, Technology, Engineering and Mathematics (CURE-STEM) within the College of Mathematics and Science. Its core is an incentive system that is based on reassigned time for faculty members, with the understanding that these faculty members will pursue scholarly activities that promote student learning. Below we describe the institutional context for this model, the key elements of the model, and the results from the initial three years.

The University Context: Transformative Learning

In his book *Our Underachieving Colleges* (2006), Derrick Bok makes the compelling argument that the retention and graduation rates of today's students can best be improved by engaging them more deeply in the university experience. Since 2004, Central Oklahoma has been building a program of transformative, experiential learning with the goal of creating the kind of high-impact educational practices described later by Kuh (2008).

Collaboration among university divisions, particularly the Divisions of Student Affairs and of Academic Affairs, ultimately resulted in the university outlining the "Central Six" themes for Transformative Learning: 1) discipline knowledge, 2) leadership, 3) research, scholarly, and creative activities, 4) service learning and civic engagement, 5) global and cultural competencies and 6) health and wellness (Barthell *et al.* 2010). The university is intentionally advancing these themes by creating a center and director for each, reallocating resources, developing and assessing outcomes, and providing opportunities for faculty enhancement. For example, direct support for CURE-STEM has been made possible by

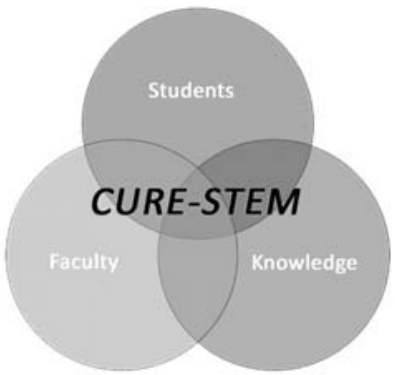
formalizing the redistribution of indirect costs to favor the principal investigator on research grants and the investigator's college: 30 percent of indirect costs are now directed to the principal investigator (PI), 30 percent to the PI's college, 20 percent to the university's Office of Research and Grants, and 20 percent to the university's education and general (E and G) fund.

The Inception of CURE-STEM

In the fall of 2004 one of the authors (Barthell) attended an "Institutionalizing Undergraduate Research" conference held at The College of New Jersey, where he met Michael Nelson, who was at that time serving as the dean of the College of Science and Health at the University of Wisconsin at La Crosse (UW-L). Nelson, a Council on Undergraduate Research facilitator at the conference, described his practice of investing $5,000 in each incoming faculty member willing to arrive early on campus (the summer prior to his or her first semester in the classroom) and willing to produce a complete grant proposal within a year. This practice was continued over a five-year period at La Crosse and, in the spring of 2010, the return on investment of this practice was reported by his colleagues (Agarwal and Sudhakaran 2010). They found that over the five-year period, $90,000 was invested in 18 faculty members, ultimately yielding $1,473,923 in grants in return, a dollar ratio of 16.4 to 1. These results made it clear that by encouraging faculty to write and submit grant proposals to external funding agencies, funding levels increased, along with support for research involving undergraduates. In other words, student-centered research has the potential to pay for itself.

When three new deans (dean, associate dean, and assistant dean) of UCO's College of Mathematics and Science first assembled in 2006, they were a group with demonstrable records of grantsmanship, and they supported the concept of student-centered research initiatives through faculty development. Together, they developed the framework for a center that would not only add revenue to the college, but also clearly support the premise of a student-centered educational environment. The group adopted (and slightly modified) the model outlined by Elgren (2004), who discussed and illustrated a concept for understanding the relationships among faculty development, student learning, and new knowledge. The deans stated the mission of CURE-STEM this way: Promote undergraduate research and curriculum innovation by encouraging faculty development and student learning in a fiscally sustainable manner. A modification of the tripartite scheme of Elgren *et al.* (2004) was produced to symbolize the center's goals and mission (see Figure 1) and to visually link the CURE-STEM program to the similar mission of the Council on Undergraduate Research (CUR).

Figure 1. CURE-STEM logo as modified from Elgren (2004).



Building Support: Presenting the Plan to Faculty and Administrators. The creation of a center on campus requires approval by the provost and president of the university. Before recommending approval to the president, the provost seeks input from his cabinet, consisting of deans, representatives from the Division of Academic Affairs, and other campus administrators. Prior to formally presenting the idea to the cabinet, the dean of the College of Mathematics and Science gave 12 preliminary presentations detailing planning processes at both the college and academic affairs levels. He made these presentations to each college department that accepted his offer to listen to a presentation and also to college faculty members at a venue known as the Research Roundtable. This gathering, developed by the assistant dean of grantsmanship, provides the opportunity to rapidly assemble faculty to report on progress of new initiatives that impact the college.

Building Resources: Integrating Sponsored Programs with the College. In preparation for the center's emphasis on student-centered grantsmanship, the college (through a reallocation of funding) developed an Office of Sponsored Programs (OSP) in the spring of 2008. The OSP works directly with faculty members, supporting them in proposal development, preparation, and submission to federal and state agencies; it also handles post-award reporting, purchasing, and budget management. Situated in the center of the main science building adjacent to the deans' office, the OSP provides much-needed proximity of its staff to faculty members. The development of a physical space for sponsored programs (housing an assistant dean, a director, and an administrative assistant) is unique on the UCO campus and provides a direct link to the university's Office of Research and Grants, greatly diminishing the logistical issues previously associated with writing and routing grants for faculty members.

Working with the dean to support and encourage CURE-STEM Scholars (described below), the OSP has played an important role in the development and success of CURE-

STEM. Apart from a director and assistant dean, the OSP has only one staff member, an administrative assistant, who shares budgetary and reporting responsibilities for funded grants with existing staff among the various subunits within the deans' office in order to minimize costs. Accordingly, a critical new understanding of the importance of grantsmanship to the operation of the college has developed throughout the OSP and the dean's office staff as a whole.

Key Elements of CURE-STEM

Faculty Scholars and Participants. CURE-STEM incorporates two categories of faculty members: Scholars and Participants. CURE-STEM Scholars, the faculty who receive the most funding from the center (in the form of reassigned time, student stipends, and the like) are expected to apply for external funding as delineated in a written memorandum of understanding (MOU) signed by the dean, department chairperson, and faculty member. The MOUs are renewable and are written for a term of four years for new tenure-track faculty members and three years for existing tenured faculty members. CURE-STEM Participants do not sign an MOU and do not receive an annual budget, but they receive support for page charges for their research publications and for poster printing, and they are considered for funding for travel with students when such opportunities arise. Both faculty groups post their biographical information and photographs on the college website to encourage students interested in their research to contact them.

It was clear from the beginning that the ability to successfully develop and allocate resources was the most critical factor in determining if CURE-STEM would be sustainable. Resources are essential in promoting faculty support for the program, and we identified five critical types of resources for inclusion in the CURE-STEM Scholars package. These are briefly summarized in Table 1 and are described more fully, below.

Faculty Reassigned Time. The most critical element of the CURE-STEM package is faculty reassigned time. At UCO, faculty members are assigned a 12-hour course load per semester. These heavy teaching loads, coupled with equally heavy service expectations, leave little time for faculty members to work with students, let alone develop research programs and proposals leading to external funding. This issue is a leading concern among PUIs attempting the transition to an environment that encourages the teacher-scholar model.

Although we realized that offering reassigned time for faculty members to pursue research funding would necessitate an increased reliance on adjuncts, we did not foresee a simultaneous increase in demand for additional course sections due to an enrollment spike during this same time period. The resulting increased budget for adjunct faculty provided by academic affairs made possible the financial support of reassigned time for CURE-STEM Scholars, though availability of adjuncts was an issue in some departments. The college dean, department chairpersons, and CURE-STEM Scholars worked collaboratively in these instances to find creative solutions. For example, some Scholars teach their full load in the fall semesters when class demand is the highest and receive six hours of reassigned time in the spring semesters. Similarly, an agreement was reached that allows masters students to teach lower-division science laboratories and developmental mathematics courses, thereby eliminating the need to replace reassigned faculty members with adjuncts in those sections.

Table 1. Summary of support and costs for UCO CURE-STEM (Faculty) Scholars during the three-year initial development of the program.

Type of Support	Cost per Scholar	2008-09	2009-10	2010-11
	Scholars Supported Per Year	4	13	17
25% (6 of 24 hours) faculty reassignment per year (adjunct replacement)	$5,340	$21,360	$69,420	$90,780
Stipends for undergraduate researcher(s) throughout the academic year: (5 hrs/wk) x ($8.00/hr)	$1,000	$4,000	$13,000	$17,000
"Development" travel (e.g., travel to a Council on Undergraduate Research meeting, a trip to Washington, D.C., to meet an NSF program director, etc.)	$1,500	$6,000	$19,500	$25,500
Support for faculty member and student to travel to a professional meeting where the student is presenting	$2,500	$10,000	$32,500	$42,500
Grant proposal writing workshop	$250	$1,000	$3,250	$4,250
Total Support	$10,590	$42,360	$137,670	$180,030

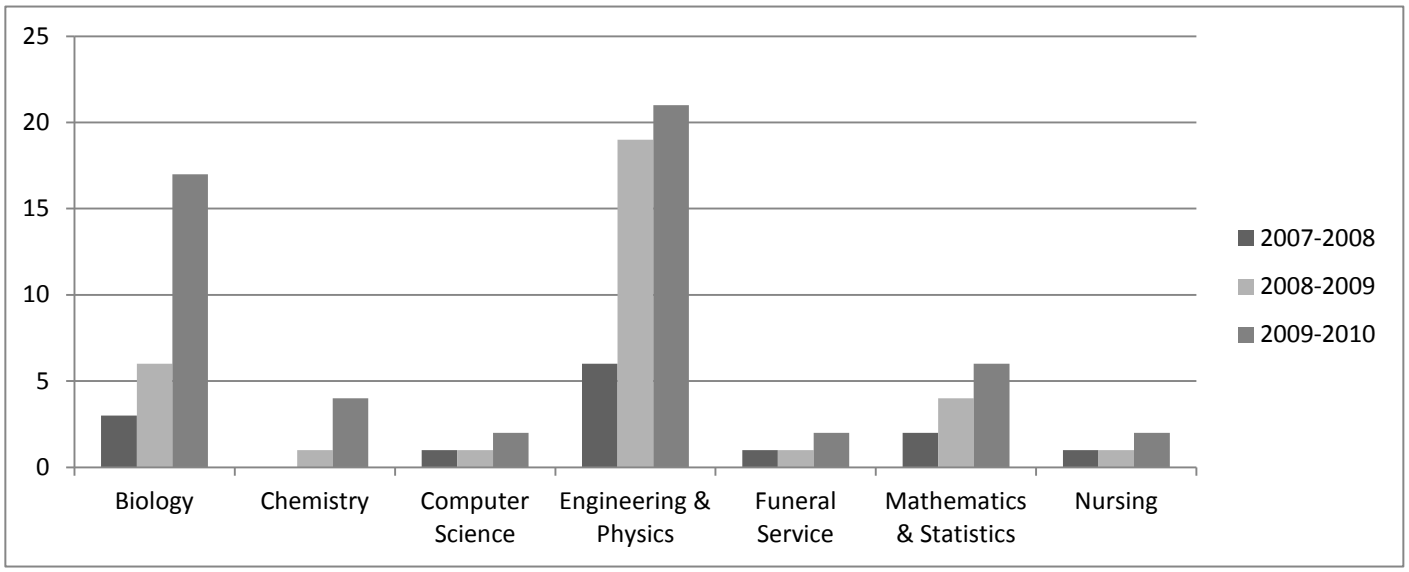
Stipends for Undergraduate Research Activities. To be consistent with the number of hours undergraduates work on campus in other roles, we would ultimately like to support one or two undergraduate researchers for each CURE-STEM Scholar for up to 20 hours per week, with additional funds available for summer support. Providing this level of support did not prove to be economically feasible, however, since our only available funding was from fixed operating funds from tuition revenue and state funding. By reallocating funds in the college's operating budgets, however, we were able to allocate $1,000 initially to each CURE-STEM Scholar to support one student for five hours per week. (This amount has recently been increased to $2,500.) Although this amount is not optimal, several Scholars were able to combine this with other funding sources (external grants and on-campus grants from the Office of Research and Grants) to pay students to work additional hours each week.

Support for CURE-STEM Development Travel. To assist Scholars in developing successful grant proposals, we recognized that it would be beneficial for them to periodically travel to the National Science Foundation (NSF) and/or the National Institutes of Health (NIH) to meet with program officers. We also knew that they would need to participate in meetings of discipline-specific organizations that promote undergraduate research, as well as broader organizations, such as the Council on Undergraduate Research (CUR). We call this type of travel "CURE-STEM Development Travel" (see Table 1). The funding in this category has recently been increased to $2,000 with a more discretionary range of student-centered expenditures available to the faculty member. Such changes were made in direct response to concerns of the faculty members regarding not being able to fully utilize this budgetary line each year, as well as our own monitoring of the use of these funds. So although we still promote these activities, we also recognize that during some years a CURE-STEM Scholar might better use this funding to support research with students (field travel, supplies, etc.).

Support for Travel with a Student. Our academic course fees may be used to support students traveling to professional meetings along with their faculty research sponsors. Each department in the college is given a budget to support such student travel. As the CURE-STEM model was developed, a portion of these funds was designated for use by students working with CURE-STEM Scholars. Faculty members may not use these funds unless accompanied by a student coauthor. In many situations, the student is the primary presenting author.

Grant-Proposal Writing Workshop. The Oklahoma State Regents for Higher Education sponsors an annual grant-proposal writing workshop that provides opportunities for faculty members to work on grant proposals while obtaining feedback from successful proposal writers and/or reviewers. Although we initially required CURE-STEM Scholars to attend this workshop, the college now offers its own version, partially modeled on the state regents' approach but more specific to the goals of CURE-STEM Scholars.

Figure 2. Number of grant proposals, by department, submitted by faculty members in the College of Mathematics and Science since 2007. (Note that numbers of faculty members vary among departments.)



Results of the Center's Activities

Intended Consequences of CURE-STEM. As noted previously, the key premise of CURE-STEM is the promotion of student learning through development of faculty interests in student-centered research. One measure of whether students are interacting with faculty is the number of poster presentations they create together. In Oklahoma, the largest interdisciplinary event for such presentations is Oklahoma Research Day (Hensel 2004). Since the initiation of CURE-STEM, the number of posters reported for faculty and/or students in our college has steadily increased from 67 in 2008 to 142 at the 2010 event. Given that the total number of full-time faculty and graduate students in the college has not changed appreciably during this time period (an increase of 7 faculty and a decrease of 6 graduate students), this increase in poster presentations is indicative of more undergraduates in the college engaging in research (UCO 2011). Another indicator of this phenomenon is that the overall number of undergraduates in the college applying to the Office of Research and Grants' Student Grant Program increased over this same time period from 10 to 25. (These grants are based on merit and include a stipend for up to five hours of work per week, a partial tuition waiver, and funds for travel and/or supplies.) We believe this increase in activity is a synergistic effect of support from the grants office and CURE-STEM, among other factors, with committed faculty mentors driving the results.

The College of Mathematics and Science has a grant from the NSF Science Talent Expansion Program (STEP), the primary component of which is a four-week residential summer research program for incoming freshmen in STEM fields. Students work in small groups on an original research project under the supervision of a faculty mentor. STEP participants are encouraged to continue to conduct undergraduate research throughout their freshman year and beyond. With more than one-third of the 103 full-time faculty members in the college currently participating in CURE-STEM as either a Participant or a Scholar, CURE-STEM has made it possible for 65 of the 95 (68 percent) STEP students over the past three years to participate in research beyond the initial summer experience. Moreover, the retention rate of all students in the 2010 STEP cohort from their first to second year of college was 81 percent (29 of 36), compared to 96 percent (25 of 27) for the subset of cohort students who were involved in research during their freshman year. The university's STEP data are in sharp contrast to the overall first-to-second year retention rate of 48.3 percent for the university's STEM students (CSRDE 2011).

This increased retention rate also correlates with increased GPAs. The average GPA at the end of the freshman year of the 95 STEP participants is higher for those who participated in research: 2.42 for the students not engaged in research during their freshman year, 2.98 for those engaged in research for at most one semester, and 3.15 for those engaged in research for both semesters.

The recently funded NSF Scholarships in STEM (S-STEM) Program at the university provides scholarships to former STEP participants with financial need; awardees are encouraged, but not required (per NSF regulations), to continue working on research with faculty mentors. Of the 53 S-STEM participants from the first two cohorts (2010 and 2011), 87 percent (34 of 39) participants involved in undergraduate research have been retained in STEM majors, compared to only 50 percent (7 of 14) who elected not to engage in research. Even more striking is the contrast between the first-to-second-year retention rates of the freshmen in the first cohort of S-STEM Scholars who participated in research during their freshman year versus those who did not: a 100 percent (19 of 19) retention rate for research participants versus a 25 percent (1 of 4) rate for non-research participants.

Another intended consequence of CURE-STEM was the development of a successful model that encourages faculty submission of grant proposals in support of student-centered research activities. Indeed, there was a four-fold increase (from 13 to 52) in proposal submissions from college faculty members three years after the first CURE-STEM Scholars were identified in 2007. At the level of departments, by the third year we observed increases in not only the traditional STEM Departments of Biology, Chemistry, Computer Science, Engineering and Physics, and Mathematics and Statistics, but also from the Departments of Funeral Service and Nursing (see Figure 2).

A key outcome of increased proposal submissions was an increase in funded proposals. External funding received by the college has increased more than two-fold since 2007-2008 (see Figure 3). This included increased funding for indirect costs, which could then be used to better support a culture of grantsmanship elsewhere on campus through the direction of 40 percent of those indirect cost reimbursements to the Office of Research and Grants and to institutional (E and G) funds at the university level.

Over a three-year period, $360,060 was invested in 17 CURE-STEM Scholars, yielding $4,344,538 in external grant revenue for the college (see Figure 3). Our overall investment ratio after the first three years of the program is therefore 12.1 to 1, even considering the increased investment by the college and the increased diversity of programs supported.

Unintended Consequences of CURE-STEM. Although many of the predicted outcomes for CURE-STEM began to emerge for our college, some ancillary benefits were not necessarily predicted and may be only loosely connected to the existence of the center. Indeed, enrollment of under-

Figure 3. Amount of funding received by the College of Mathematics and Science since 2007.

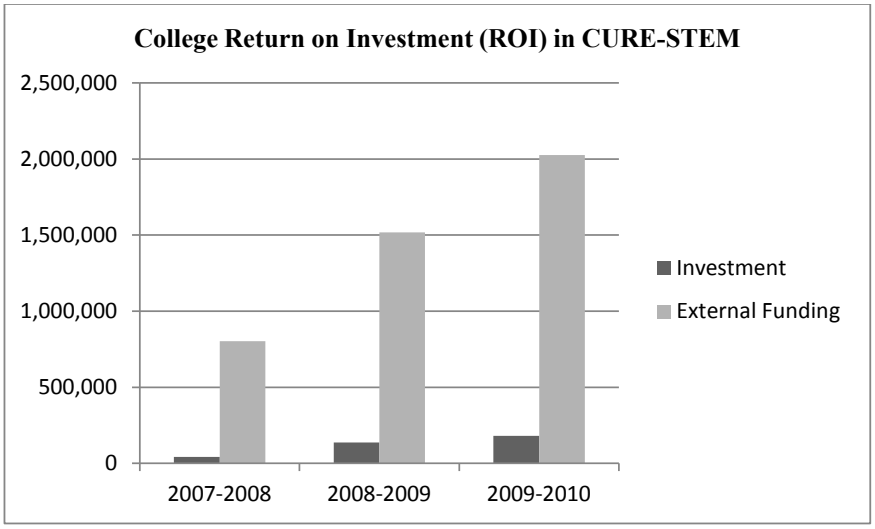
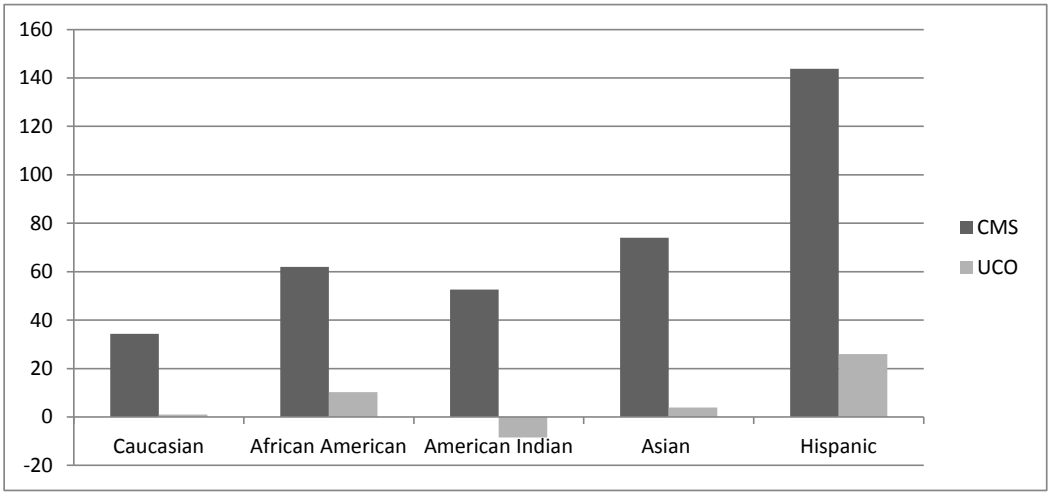


Figure 4. Growth in student diversity in the College of Mathematics and Science versus the UCO campus as a whole: percent difference Fall 2006 to Fall 2010.



graduate majors in the college has increased by nearly 50 percent in five years, from 2,029 to 3,003 majors, along with a simultaneous increase in credit-hour production of 5,587 credit hours. There has also been a conspicuous increase in students from underrepresented groups over this same time period (UCO 2011). For example, as depicted in Figure 4, the number of American-Indian majors in the college has increased by 52.6 percent (from 97 to 148), while the comparable total of American-Indian students in the university as a whole has decreased by 8.5 percent (from 859 to 786). Although we cannot attribute this increase in diversity solely to undergraduate research opportunities and CURE-STEM activities, we have seen a concomitant increase in NSF funding that supports underrepresented groups (e.g., S-STEM).

Besides the additional funding for indirect costs the university has received through the increase in externally funded grants, there have been other examples of how the presence of CURE-STEM has been a mutually beneficial initiative for the Central Oklahoma campus. For example, since the university's policy is to distribute salary savings from external grants to faculty across campus in support of grantsmanship activities, salary savings generated by the College of Mathematics and Science through its collaboration with a National Institutes of Health INBRE (IDeA Network for Biomedical Research Excellence) grant program have supported reassigned time for faculty in other colleges. Indeed, following an INBRE-related site visit to the university in 2010, a team from the American Association for the Advancement of Science (AAAS) recommended that the CURE-STEM model be presented to other regional universities in the state through the formation of a new organization of deans (the OK-INBRE Deans' Council), in order to promote better ways of encouraging undergraduate biomedical research (AAAS 2010). Leveraging both the CURE-STEM Scholar package and the INBRE collaboration, the college recently was able to hire four new faculty members (in existing salary lines) who would otherwise not likely have considered working at the university.

We expect CURE-STEM to continue to develop collaborations within the university and among institutions. With undergraduate research becoming increasingly important for the future of STEM (and other) disciplines, our ability to leverage more support for faculty members to handle these responsibilities will become increasingly important. The next challenge will be to better integrate student-centered research practices with tenure and promotion processes, a task that has already begun on the campus. (See the Summer 2011 issue of *CUR Quarterly* for more information on this

topic.) Key to this integration is the recognition of the faculty time and resources needed to engage in such research. As the literature now indicates so clearly, students will benefit when faculty members are given opportunities to participate in undergraduate research.

Acknowledgement

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