Instructional Faculty Development and Student Success

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Introduction

Boise State University is a metropolitan public university in the state capital and the largest institution of higher education in Idaho. The College of Engineering was established in 1997 in response to regional demand for engineering education from Micron, Hewlett Packard, and other industry leaders. Despite the formation of the college, which in less than 20 years now has an enrollment of nearly 3000 students, there remains a steady and ongoing need for technically trained STEM graduates. For example, as of fall, 2015, the regional demand for computer scientists is estimated at 10:1 or more as a result of the rich computer science industry located in Boise, with hundreds of small startups and dozens of mid-sized software companies. Thus, the project's overarching goal was to increase the number of high quality, technically trained engineers and computer scientists who graduated with B.S. degrees.

As a result of this demand for technically trained graduates, STEM enrollment at Boise State University has grown steadily for more than a decade. Between 2002 and 2008, STEM enrollment grew by ~1400 students; this growth was again seen between 2008 and 2014. This relentless growth exposed several issues that the Idaho Science Talent Expansion Program (Idaho STEP) grant's effort helped address. One of these was a very low first-year retention rate. At the time the grant was submitted, we had seen first-time freshmen retention for the 2008-2009 academic year of only 57% for STEM majors.[1] We had a pretty good idea why we had low retention – we had low pass rates in mathematics classes, for example. An example of this, was an average pass rate in 2005-6 in Calculus I of only 51%.[2] Thus, during the grant funding period, we had issues to resolve: we had very low retention in STEM majors, we had low pass rates in Calculus and other mathematics, engineering and science courses, and on top of it all, during the five-year grant funding period, the number of STEM majors kept steadily growing, fueled by the roaring regional demand for STEM professionals.

Approaches Used and Results:

Our project used three main approaches; we had a diverse leadership team, we focused on instructor development using year-long faculty learning communities, and we supported several, targeted curricular, extra-curricular and co-curricular activities for students. These are described below, with an emphasis on the first two strategies which distinguish this project from many others.

<u>A. Diverse Leadership Team:</u> A highly diverse project team was selected by the Principal Investigator (PI Callahan) to participate as co-principal investigators (co-PIs) in the project. Our leadership team consisted of five members who brought diversity both

Submitted as a paper presentation to: "Envisioning the Future of Undergraduate STEM Education: Research and Practice Symposium, Washington D.C., April 27-29, 2016.

in terms of the position they held at the university as well as in their field of specialization. This diversity brought strength. It was enormously impactful, for example, to have the Chair of Mathematics and the Director of the Center for Teaching and Learning as co-PIs; this combination resulted in very significant engagement of mathematics faculty in professional development activities. One of the co-PIs was a lecturer in physics; with increasing numbers of entry level math and science courses being taught by full-time instructors, he brought a valuable perspective to the project. All of the leadership team routinely taught first year courses and had a strong affinity for student success. In forming the team who wrote the proposal, the PI selected three of the investigators based upon whom she had observed voluntarily showing up on a routine basis for summer orientation events. The team transcended college boundaries – while the PI was associate dean of the college of engineering, only one other co-PI was from engineering, with two other members of the team coming from the college of arts & sciences (physics and mathematics). Finally, our Director of the Center for Teaching and Learning, Shadle, as a chemist and an expert in STEM pedagogy was a natural fit for the project. The program activity she directed, providing three year-long STEM focused faculty and instructor learning communities (FLCs) proved to be highly impactful. Additional details about the FLCs, including details on implementation and how they evolved over time, are presented in the following section.

B. STEM Faculty and Instructor Leaning Communities (FLCs): In reflecting on the Idaho STEP project at its conclusion, the leadership team believes the most impactful activity, by far, was the prolonged exposure to evidence-based instructional practices (EBIPs) that STEM instructional faculty experienced during this project; this is therefore the primary focus of this paper. We accomplished this professional development through the use of year-long instructional faculty learning communities (FLCs) that provided training on innovative teaching strategies. Faculty learning communities are a unique kind of community practice[3] that have been shown to impact teaching practice.[4] More than just a seminar series or faculty task force, FLCs have the potential to transform institutions into learning organizations. Three such FLCs were held, impacting thirty STEM faculty across five years.

We approached this activity by holding our first STEM focused FLC, FLC-I in the first program year, fall 2010. Eight faculty participated, from chemistry, physics, mathematics, materials science and mechanical engineering; they had either tenure line or lecturer appointments. FLC-I began with a two-day retreat before the fall semester commenced, and continued across the fall and spring semesters with a meeting every other week. Each meeting lasted for 1 hour and 45 minutes and used discussion, presentation, reflection, sharing and readings to engage in deep exploration of various teaching and learning topics. To incentivize participation, FLC-I participants received $1500 to use for their research, and a one-course buyout that was funded by the grant.

During the FLC-I meetings, facilitated by Shadle, participants rotated the responsibility for leading meetings. Each meeting focused on a specific topic relevant to STEM teaching and learning, including best-practice pedagogies, frameworks for student development, strategies for assessment, dealing with student misconceptions, a discussion of institutional student success data, and how STEM disciplines frame the context for teaching and learning.

The next year we spent assessing FLC-I by conducting an analysis of participants' teaching logs or journals. A content analysis exposed trends and themes; the result of this analysis is presented elsewhere.[5,6] One conclusion drawn from this analysis related to the critical importance of reflection: being a member of FLC-I played a critical role in supporting reflection, and likely primed participants for future changes in their teaching.[7,8]

FLC-II and FLC-III were conducted in the third and fourth year of the grant. As a result of the STEM enrollment growth, the departments of physics and chemistry were unable to contribute faculty because they would not be able to meet student demand for their course offerings. Consequently, we focused FLC-II exclusively on the subject of Calculus I. Thus, FLC-II was a single-discipline group, comprised of ten members, focused on a single set of courses. Outgoing department chair, co-PI Bullock had been laying the groundwork for focused revision of this particular course for some time. While Shadle continued to facilitate FLC-II, Bullock's leadership and effort was critical to the recruitment of faculty and also to its success.

We funded this FLC slightly differently; four "core" faculty members received either summer salary or a course reduction buyout to focus on a project aimed at improving success in calculus. Six affiliate faculty attended meetings and contributed to the development and completion of the core faculty projects. The goal of FLC-II was to explore and experiment with strategies at both the individual and institutional level in order to make recommendations about practices that would substantively impact student learning and success in calculus, and structures within which these practices could occur.

A critical development occurred; faculty in FLC-II who were teaching Calculus I piloted the use of three common final exam questions. The questions were co-written by the FLC-II faculty. This yielded several insights: 1) the grading on the questions was very similar between instructors, despite no agreed upon rubric; 2) students in all sections struggled with similar difficulties; 3) there were some student difficulties that seemed to stem from wording of the questions. The experiment was very useful in helping people to see potential value and challenges in having common exams, and laid the groundwork for improved assessment practices.

The exploration conducted in FLC-II laid the ground work for Bullock to propose a common calculus offering. This was partially supported through an internal, provost-funded grant in spring 2013. This offering involved some of the same calculus instructors as in the FLC-II, as well as some additional faculty. FLC-III continued to focus on Calculus I. Instructors worked together in the fall 2013 term to develop a common course design. In the spring 2014 term all instructors taught the course from the common materials. While adoption of common pedagogy was not required, an active, problem-solving focused approach emerged through discussion and practice and all faculty teaching Calculus I now use this approach. FLC-III participants included: 3 tenured faculty; 5 full time lecturers; and 2 part time adjuncts. The common calculus offering has now been delivered every semester since spring of 2014.

As of 2016 we now have a coordinated calculus offering that employs common homework questions, has common exams, uses similar pedagogy and has a common final exam. We presented the method by which we facilitated the reform of this course at ASEE in 2015;[9] this approach was sufficiently compelling that the paper received the mathematics division "Best Paper Award." Table 1, below, summarizes the key strategies taken to accomplish the development of our coherent calculus course. We learned that reform starts from within – it is not a result of a course coordinator being appointed, or a common syllabus of final. A coordinate course is based on common homework problem. Having common homework problems leads to natural commonalities on quizzes. A dialogue on how to weight course elements works better than imposing a common syllabus. Over time, we found course instructors naturally wanting common exams and finals; these were not imposed. We measured pass rates, percentages of students earning certain grades; some of these results are presented below, with full details presented elsewhere.[9]

Table 1: How to create a coordinated course with a common pedagogical approach

Adoption Strategy – NO – Do not do this!	**Adoption Strategy – YES – Do this:**
Appoint a course coordinator.	Start with common homework. Build consensus agreement on every exercise.
Combine 12 small sections into 2 huge sections.	Do the same thing with quizzes.
Impose a common syllabus.	Agree on basic weighting of all Hw, Qz, Ex, Final and letter-grade cutoffs.
Impose a common final.	Build consensus on exam content – eventually reach common exams.
Impose common midterm exams and final	Eventually adopt a common final
Impose a pedagogical model.	Along the way, allow the course content to shape pedagogy with the strategic goal, for example, of active learning.

Some of our results from the coherent calculus course:[9]

- The pass rate across the six instructors who taught in fall, 2014 increased from a weighted average of 60.5% to 73.9%
- The percentage of students earning A and B grades increased markedly, from 34.4% to 48.6%, an increase of 14.2%.
- Student course survey results commented heavily on the pedagogical approach. For many students, the opportunity to work in groups in a math class was quite different from what they had experienced in the past.

- Instructors reported spending less time lecturing, as they surrendered time in class for students to work instead of watching them solve problems.
- All but one instructor in this curricular reform project reported this impacting their pedagogical approach in other courses.
- Instructors reported improved attendance and many other benefits.

C. Curricular, Co-curricular and Extra-curricular Activities: In addition to the FLCs for instructional faculty, a number of different activities were conducted across the grant period. The first of these, accomplished in the first summer of the grant period, was to deliver a coordinated STEM summer orientation session.[1] The very act of proposing and coordinating "STEM" orientation was our first step taken on campus to establish a "STEM Identity."[10] Other projects focused on undergraduate research experiences, on-line mathematics learning/review and the Introduction to Engineering course.[1,11-13]

In addition, we developed an outdoor STEM Summer Adventure experience for entering freshmen; we took them rafting on the Payette river in Idaho for a multiple day, extended field program.[14] This is an institutionalized activity which grew from a handful of participants in 2010 to over 30 in 2015.

Idaho STEP Program – Original Outcome Statements:

By the end of the grant funding period, the Idaho STEP program will:

(1) Have increased the first year retention level of first-time freshmen from 57% by 10 to 15% for STEM majors, with a target level of 70%. This represents an annual gain of approximately 35 retained first year STEM students.

(2) Have increased STEM undergraduate degrees by 22% (reference data: there were 163 STEM graduates in 2007-8).

(3) Have increased the first year retention rate of at-risk freshmen engineering students by 10%.

(4) Continue to post gains in women engineering enrollment from 9.8% in 2005 to 12.8% in 2008, attaining 15% or more by program's end.

(5) Have institutionalized freshman STEM Learning Communities and Orientation programs.

Idaho STEP Program – Actual Outcome Results:

(1) Significant progress: We increased first-year retention of first-time freshmen by 7%.

(2) Accomplished: We increased STEM undergraduate degrees from 234 graduates in 2009-10 to 454 in 2014-15, an increase of 93%.

(3) [note, because of institutional data restrictions, we had to reframe the goal] We increased the percentage of underrepresented minority students in engineering and computer science from 10.6% in fall 2009, to 13.5% in fall 2014.

(4) Accomplished: We increased the percentage of women in engineering and computer science from 12.8% in fall 2008, attaining 15.6% by program's end.

(5) Accomplished: We institutionalized the freshman STEM Learning Communities and Orientation programs.

Broader Impacts

We report that the strategy of focusing on student retention in the first year, led by a diverse team with a two-pronged approach that included faculty development as well as student programming, has yielded positive results. This project aimed to increase overall STEM graduation numbers while also increasing the percentage female and underrepresented minority (URM) students enrolled in engineering and computer science. Across the grant period, STEM enrollment increased from 2,238 in fall of 2008 to 3,778 in fall of 2014 while first-time, full-time retention of STEM students increased by 7% (attaining 64%) and graduation numbers grew from 163 in 2007-8 to 402 in 2013-2014, an increase of more than 200%. Along with these very strong outcomes, we additionally increased female enrollment which attained 14.9% (up from 12.8% in fall, 2008) and increased Hispanic enrollment from 8.1% to 13% across the same time frame. This compares favorably with the %URM in the state (14.3%, of which 11.6% are Hispanic). We attribute this increase to improved retention, resulting from improved student learning experiences.

One of the broader impacts of this grant involved drawing attention to the needs of undergraduate STEM students. We essentially created a "STEM Identity" on campus.[10] One of the long-lasting inter-institutional outcomes realized was an awareness of the fact that STEM students had lower retention levels in STEM than the general student population, despite being among the best students admitted. Our STEM students were capable; they needed improved first-year experiences to remain STEM majors.

Finally, this award helped show the need for coordination of STEM initiatives and for the need for reliable data. In January of 2015, the Institute for STEM and Diversity Initiatives was formed; the Institute's aim is to build a diverse community of students, faculty, and others involved and invested in STEM. The primary goal of the Institute is to promote a culture of active inclusive excellence in STEM at Boise State University. The Institute fosters diversity in STEM through (a) advocating for and nurturing underrepresented student and faculty success inside and beyond the classroom, (b) strengthening avenues of communication and collaboration among University and external partners, and (c) conducting and catalyzing STEM educational research.

Intellectual Merit

Across the five years of funding and a no-cost extension, between January 2010 and December 2015, ten papers were published. These included two journal publications[5,15] and eight proceedings of the American Society for Engineering Education.[1,6,9-13,16] In addition, five posters, two workshops and one panel discussion were presented at the National Science Foundation annual STEP meetings.[17] Finally, two webinars were presented through STEP Central (now STEM Central).[18] In addition, numerous internal communications, press releases, seminars, learning communities and more were conducted in order to broadly disseminate our program results.

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Biographical Information

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Doug Bullock is an Associate Professor of Mathematics at Boise State University. His educational research interests include impacts of pedagogy on STEM student success and retention.

Susan E. Shadle is the founding Director of The Center for Teaching and Learning at Boise State and Professor of Chemistry and Biochemistry. Susan has served on the National POGIL (Process Oriented Guided Inquiry Learning) Steering Committee and as the POGIL Project's Scholarship of Teaching and Learning (SoTL) coordinator. Her scholarly interests are focused on inquiry based learning and other active learning pedagogies, faculty development, and institutional change in Higher Education.