Innovative Administration Supports Innovative Education

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Abstract **- Louisiana Tech University's College of Engineering and Science has over ten years experience operating under an innovative multidisciplinary administrative structure which has created a supportive environment for numerous education reform initiatives. The traditional departmental structure was dismantled in favor of a much more flexible approach which has helped remove barriers between departments and promoted collaboration between engineering and science programs. The new administrative structure relies heavily on multidisciplinary teams and has been a key factor in the successful establishment of our first Integrated Engineering Curriculum in 1997, followed by our Integrated Science Curriculum in 2002. Other innovations implemented since that time include the first undergraduate nanosystems engineering degree program in the US; multidisciplinary design courses which include engineering, business, and technical writing students; a freshman enrichment program; the Living *with* the Lab curriculum (the most recent version of our Integrated Engineering Curriculum); and a program whereby engineering and science majors complete the Master of Arts in Teaching and become certified K-12 teachers. The College currently has $3.5 million in NSF funding for STEM projects. Much of the lasting success of these education reform efforts can be attributed to the supportive, interdisciplinary approaches the College uses in all of its core functions, including undergraduate education, research, and graduate education.**

Index Terms – collaboration, flexible administration, innovative STEM projects, multidisciplinary structure, strategic planning

BACKGROUND

In 1994, spurred by discussions with the college and departmental advisory boards, the College of Engineering at Louisiana Tech University began the process of restructuring to create an environment that would enable and support a more innovative, integrated approach to education and research [1]. Discussions were expanded to include faculty and staff in each of the programs within what is now the College of Engineering and Science (COES), and a new administrative structure was established in 1995 (see Figure 1). Built around multidisciplinary teams and multidisciplinary interactions at all levels, and with the goal of being flexible and responsive, the new structure was designed to break down the traditional barriers that often interfere with meaningful interdisciplinary efforts in academia.

OVERVIEW OF STRUCTURE

The primary administrative body in COES is the Leadership Team, consisting of the Dean, Associate Deans and Directors. Directors are responsible for one to four academic programs within the College. The mix of programs administered by a Director is determined by a variety of factors including the total number of faculty members reporting to her/him. This mix may change periodically. Directors oversee faculty and staff workload assignments, annual evaluations, raises, and the process of tenure and promotion. The Directors also encourage and facilitate intra/inter-college collaborations. Each Director also leads one of the interdisciplinary college-wide strategic plan teams. Thus, while each Director is expected to be an advocate for the programs under her/his direction, (s)he also has significant responsibilities for advancing the COES as a whole. Directors are selected for their demonstrated leadership and management abilities and not necessarily for their disciplinary affiliations. So, for example, the Director of Chemical and Industrial Engineering is a mathematician, while the Director of Computer Science and Electrical Engineering is a mechanical engineer. This approach has been successful in breaking down the traditional "silos" and resolving "turf" issues that exist in many university environments. Associate Deans have more traditionally defined duties, such as undergraduate studies, graduate studies, and research, but also lead cross-disciplinary strategic plan teams and innovative efforts in education and research. The Dean focuses primarily on development and long-range planning, and serves as a coach for the Directors, Associate Deans and research Center Directors.

Each academic program has a Chair, a non-administrative faculty appointment from within each discipline, whose primary focus is students and curricula. The Program Chair is responsible for student placement, advising, recruitment, retention, checking of degree requirements for graduation, and updating and assessing the curriculum. Program Chairs are selected by the College Leadership Team, after consultation with program faculty, for their concern for students and vision for the program, as well as for their communication and leadership skills.

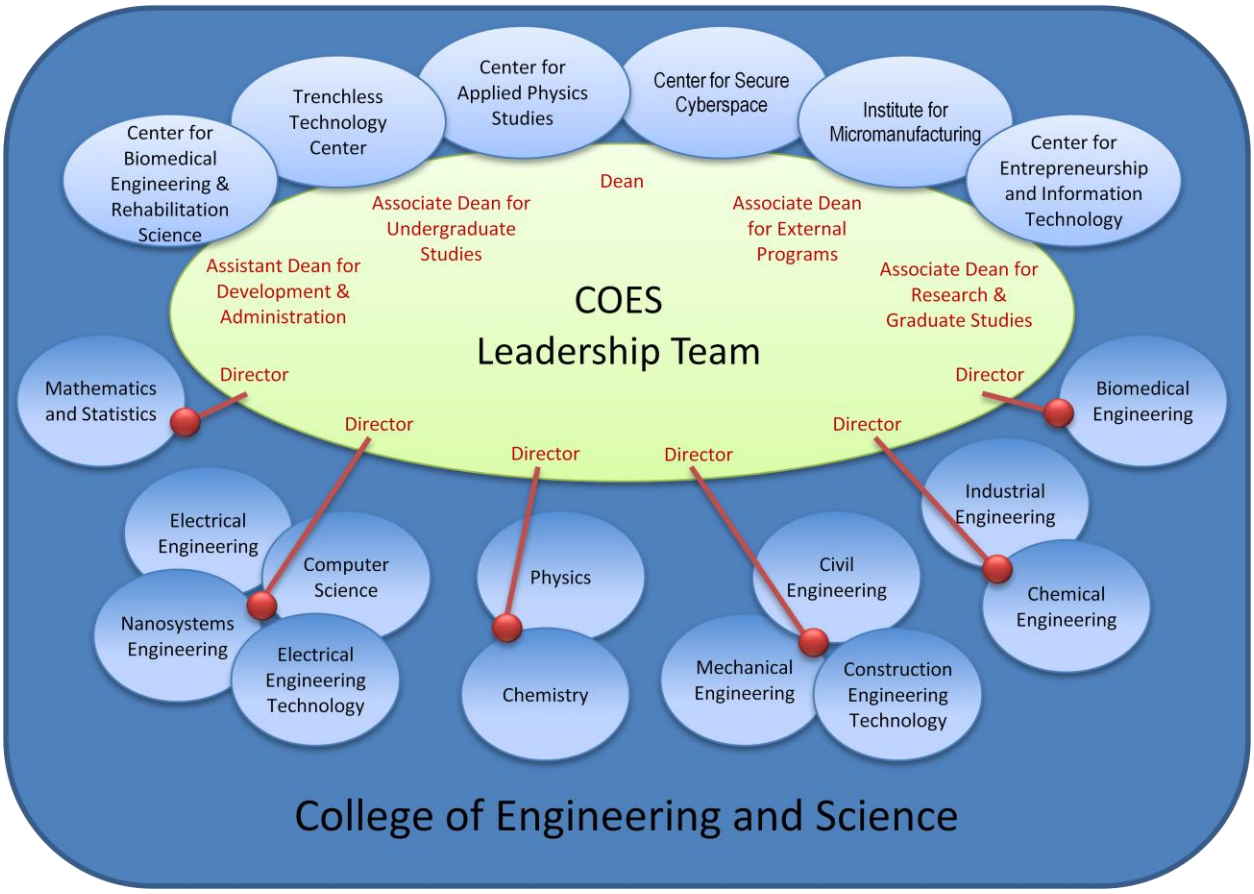

FIGURE 1. COLLEGE OF ENGINEERING AND SCIENCE ADMINISTRATIVE STRUCTURE

The College currently has six interdisciplinary research centers, each of which is led by a Center Director who reports to the Dean. Center Directors oversee day-to-day operations of the Center, promote collaboration, provide strategic direction, and assist with evaluation and support of faculty researchers. Because all of the research centers are highly interdisciplinary in nature, faculty from a variety of programs within, as well as outside, the College participate in each Center. Moreover, faculty are rewarded for their participation in both individual and team efforts (where they may play either a lead or a supportive role) within these centers. Because of the flexible nature of the administrative structure, new centers can be created and existing ones retired as new opportunities arise and existing goals are achieved. To ensure that centers are broadly supportive and reflective of the interests and expertise of faculty in the College and because the centers must have an interdisciplinary focus, there are internal guidelines for the creation of a center that require a track record of substantial funded activity by faculty from multiple programs.

SUPPORT FOR INNOVATIVE EDUCATIONAL PROGRAMS

Integrated Engineering Curriculum (IEC)

Soon after the College was restructured, an interdisciplinary group of faculty began developing an innovative Integrated Engineering Curriculum (IEC) in response to various national calls to reform undergraduate engineering education. The restructured College provided an ideal environment for the creation and implementation of such a curriculum. Chemistry, mathematics, and physics programs had been moved into the newly restructured college, out of the former College of Arts and Sciences. Moreover, the new focus on innovation and integration provided strong administrative support, and perhaps more importantly, active administrative involvement in the project.

Starting with a pilot freshman curriculum in 1997 and expanded to include a sophomore curriculum in 1998, the IEC was fully implemented in 1999 with support from an NSF Action Agenda grant. This new curriculum was the result of a series of in-depth discussions between faculty

members involved in teaching chemistry, engineering, mathematics, and physics. The goal of the curriculum was to integrate the engineering, mathematics, chemistry and physics courses at the freshman and sophomore levels. The engineering courses incorporated design projects and emphasized skills development in teaming, communication, laboratory experiences, and problem-solving. Each course was structured such that the material taught in mathematics was applied in the freshman chemistry course and implemented in the freshman engineering course, often in the same week. The pilot program was started with cohorts of approximately 40 students enrolled in the same block of math, engineering and science courses. The engineering and science faculty teaching each cohort of students met once a week to coordinate lesson plans and report on student progress. By 1999 all engineering majors were enrolled in the curriculum. Initial assessment showed significant improvement in student performance over the traditional program [2].

Over time, with the addition of new faculty, certain aspects of the curriculum (such as weekly faculty meetings) became difficult to maintain. Changes in technology and student preparation provided new opportunities and new challenges that did not exist in 1997. Lastly, after almost a decade of experience with innovative instructional approaches, College faculty had matured in their own understanding of effective curricula. Consequently, starting in 2005, engineering faculty began piloting Living *with* the Lab (LWTL), the second generation Integrated Engineering Curriculum.

The LWTL curriculum consists of several interrelated smaller projects culminating in a complex process control system to maintain the temperature and salinity on a container of water. Each of these smaller projects can be viewed as a self-contained project that integrates engineering, mathematics, chemistry, and physics. These individual projects seamlessly connect into a multifaceted problem that develops systems thinking in our students.

The overall project incorporates design, fabrication, and troubleshooting skills in a way that helps students develop self-reliant attitudes. For example, as a part of the overall system, the students design and fabricate a working pump for which they subsequently develop pump efficiency curves. The LWTL curriculum kept many of the successful aspects of the original Integrated Engineering Curriculum, such as integration of engineering, mathematics and science concepts; use of student teams; and student cohorts. However, it goes well beyond the original curriculum in helping students develop problem solving skills. The collaboration among faculty who developed and teach this curriculum clearly has been facilitated by the multidisciplinary and flexible structure of the College and the value that the College places on educational innovation. After two years of piloting, the LWTL curriculum entered its first year of full implementation in 2007-08 with support from NSF. For more details on this curriculum, see [3]-[4].

Integrated Science Curriculum (ISC)

Inspired by both the success of and their own involvement with the Integrated Engineering Curriculum, a group of mathematics, science, and education faculty (residing in three different colleges within the university: Engineering and Science, Applied and Natural Sciences, and Education) began meeting in 2001 to develop a freshman and sophomore Integrated Science Curriculum (ISC). This curriculum, funded by an NSF Course, Curriculum and Laboratory Improvement grant in 2003, borrowed successful aspects of the Integrated Engineering Curriculum, such as cohorts of students, integration of content (primarily focused on the six introductory science labs in biology, chemistry and physics) and faculty communication [5]-[6]. The ISC, however, had other goals more specific to its intended audience, such as an emphasis on scientific method (versus engineering design) and creating a community of learners from the science and science education majors who generally hail from smaller programs and more isolated experiences.

As with the IEC, some aspects have been more successful than others, most notably the revision of the content and pedagogy in the introductory science labs, communication among some of the science lab instructors, and a sense of community, again in the science lab courses, among the science majors. In fact, some of these gains in the science lab instruction and organization are now poised to make their way in some fashion into the new LWTL Integrated Engineering Curriculum. Moreover, the collaboration between the College of Engineering and Science and the College of Education laid the groundwork for more significant collaborations, described below.

LaTechSTEP

Louisiana Tech University's STEM Talent Expansion Program (LaTechSTEP) is an NSF-sponsored project with two major components aimed at increasing the numbers of graduates in STEM disciplines. One component focuses on recruitment of new students, while the second component increases retention of enrolled students through a Freshman Enrichment Program [7]-[8]. Our overall goal is an annual increase in STEM graduation rates from 220 students per year to a sustainable 300 students per year. Both components of LaTechSTEP utilize techniques that have proven successful in our Integrated Engineering and Science Curricula, including team building, collaborative learning, and hands-on activities. Close collaboration between College faculty and high school teachers maximizes the benefit to students by having both their regular teachers and university faculty directly involved in their projects. This team approach involving both high school teachers and university professors, along with the integration of topics**,** sets our project apart from the more traditional high school weekend science camps. Teachers have made several very positive comments on how the LaTechSTEP projects

seamlessly integrate math, science, and engineering. As a result, many of these teachers have begun to change the way they teach math and science.

Nanosystems Engineering

One of the most significant advantages to our current administrative structure is the flexibility to respond quickly to new needs. In 2005 Louisiana Tech began offering the first B.S. degree program in Nanosystems Engineering in the United States. The program grew out of our research strength in micro- and nano-technology and our interdisciplinary focus on innovative education. Nanosystems Engineering is currently the fastest growing undergraduate degree program in the College with 76 students enrolled at the present time. In a 2006 national survey by *Small Times* magazine, Louisiana Tech University was ranked 3rd nationally in micro-nanotechnology education and 15th overall in U.S. universities involved in micro-nanotechnology research and education. In a similar *Small Times* survey in 2007, Louisiana Tech University was ranked 2nd in the nation in the number of micro/nanotechnology-oriented degree programs offered.

The current interdisciplinary and collaborative culture of our College facilitated rapid implementation of this new degree program which under our previous administrative structure would have been a much more challenging and lengthy process. Currently, 14 faculty members have joint appointment in our Nanosystems Engineering program and another program within the College. Nanosystems Engineering draws upon the strengths of our unique combination of laboratory resources and interdisciplinary research, education, and support programs. In the past two years over $1.8 million in funding from the National Science Foundation has been directly applicable to program and lab enhancements for our Nanosystems Engineering program.

STEM-Plus

STEM-Plus (Louisiana Tech's NSF-funded Noyce Scholars Program) is designed to serve undergraduate STEM majors who have a strong desire to teach math and science at the high school level. Upon completion of the B.S. degree in a STEM discipline, the program provides a one-year track leading to the Master of Arts in Teaching. There is also an alternate one-year track for STEM professionals who have already completed their B.S. degree. STEM-plus will have a significant impact on K-12 school systems by providing highly-qualified teachers who have a strong contextual understanding of mathematics and science. This program was developed by an interdisciplinary team of university faculty from the College of Engineering and Science and the College of Education and is built upon current teaching techniques utilized in the Integrated Science and Engineering Curricula at Louisiana Tech.

IMPaCT and VET

There have been several other innovative educational programs that required true interdisciplinary collaboration with areas outside the College of Engineering and Science. These programs provide STEM majors (as well as some majors from outside the college) with an opportunity to broaden their education experience in innovative ways. Our NSF-funded Innovation through Multidisciplinary Projects and Collaborative Teams (IMPaCT) program incorporates a multidisciplinary senior design sequence that includes engineering, business, and technical writing students [9].

In conjunction with the College of Business and the university-wide Center for Entrepreneurship and Information Technology (CEnIT), this program has been further expanded to promote commercialization of University intellectual property. Multidisciplinary Venture Enhancement Teams (VET) create prototypes and business plans for projects that have been partially developed by research faculty. Our Innovative Product Design and Innovative Venture Research courses, team taught by engineering and business faculty, further support the goals of the IMPaCT and VET programs. The collaborative, multidisciplinary environment on our campus has significantly influenced student culture in a variety of other ways as well, such as the initiation of the Association of Business, Engineering, and Science Entrepreneurs, a student organization conceived of and inaugurated by students from the College of Engineering and Science and the College of Business.

GRADUATE DEGREES

The restructuring of the College had a significant impact on the graduate programs offered by COES, as well. In the new structure, the PhD in Engineering became a truly interdisciplinary degree initially offering two avenues of research closely aligned with the Institute for Micromanufacturing and the Trenchless Technology Center. Recently, the scope of the degree has been broadened to include the Center for Applied Physics Studies so that three concentrations are now available within this degree: micro and nanoscale systems, materials and infrastructure systems, and engineering physics. Unity of the degree is ensured by a common set of core courses, while the depth in each concentration is realized by three distinct sets of concentration courses and a wide range of electives. Among the unique and multidisciplinary opportunities provided students by this PhD degree are the use of computational chemistry in the design of catalysts for fuel cells, and the modification of the structural and mechanical properties of concrete by electrokinetic impregnation of the cement matrix by metal nanoparticles.

The College has also launched two interdisciplinary Master of Science degrees within the current framework. The MS program in Engineering and Technology Management is a collaborative effort between the COES

and the College of Business that incorporates strong entrepreneurship and technology commercialization components. Approximately half the students currently enrolled in this program at present are students with Bachelor's degrees in Business Administration. In 2003, COES also became one of the first (if not *the* first) to offer a MS degree in nanotechnology, under the title of "Molecular Sciences and Nanotechnology." A collaboration between the COES and the College of Applied and Natural Sciences, this degree program received exceptionally favorable reviews from the team of external reviewers selected by the Louisiana Board of Regents to evaluate it.

Graduate students in the COES learn and work in an atmosphere free of disciplinary boundaries. As a result, and since they are not yet contaminated by the "traditions" of traditional academia, they instinctively reach across these artificial boundaries without prodding from their advisors. As a result, a former electrical engineering major has led the fabrication of a novel nanoparticle catalyst for Fischer-Tropsch generation of biofuels (a pilot plant is operational at present) and a former physics major is developing the next generation of smart projectiles for the US Army.

CULTURAL TRANSFORMATION

In order for an administrative restructuring of this magnitude to work, a cultural transformation had to occur within the College and, to some degree, within the institution as a whole. Initially, College leaders helped faculty understand the reasons for moving to an innovative administrative structure with workshops and meetings. Even with some degree of buy-in from a core group of faculty and administrators early on, real cultural transformation took time. The Leadership Team was careful to make budgets and the decision-making process as transparent as possible. Faculty teams representing the entire college were created to accomplish the goals within each of the strategic plan areas and were empowered with real budgets and decision-making authority.

These and other efforts to establish genuine trust between existing engineering faculty, administrators and staff, as well as the mathematics, chemistry and physics programs that were brought into the College from the College of Arts and Sciences, assisted with the transformation. But the needed cultural transformation succeeded largely due to the integrated educational efforts, such as the IEC and ISC, and interdisciplinary research projects. In creating and sustaining these efforts, faculty from multiple programs worked together on a daily basis to create innovative curricula and conduct exciting new research, both of which were solidly supported and rewarded at the College-level and, in the process, came to know and trust one another. Thus the lack of trust and understanding between scientists and engineers which, at many institutions, poses a significant barrier to truly interdisciplinary education and research, was significantly reduced.

These and other early successes helped convince almost everyone in the college that this new administrative structure could actually deliver as promised. Continued successes have stirred interest across the institution as a whole, particularly with regard to interdisciplinary research, where the cultural transformation is permeating institution-wide with good success.

IMPACT ON FACULTY HIRING

The unique administrative structure has afforded the College the opportunity to utilize the faculty hiring process to support new opportunities and new approaches in education and research, as well as to meet urgent needs. As part of the overall administrative restructuring, the college budgeting processes and procedures were reorganized to better support the goals of integration and innovation. Given that program budgets consisted largely of routine items (phones, postage, supplies, etc.) which programs need each year in order to operate, all program budgets were merged into a single account that is managed by a staff team. Programs did retain control of gift accounts designated for their use, and research center budgets remained separate as well.

Under this structure, programs, research centers and COES administrators have the opportunity to think creatively about how the College can best meet its teaching and research needs and commitments, as well as capitalize on new opportunities. Such discussions take place on a continual basis but are of particular importance when hiring plans for the next fiscal year are formulated. Programs and research centers then search for and hire new faculty in areas (research or education) where they are needed most and in which they can make the greatest impact. No longer does a retiring faculty member in Program X with a specialty in area Y have to be replaced with someone who looks just like him/her (although there is nothing to prevent such from happening if, in fact, that is an important need or opportunity). Moreover, the centralized approach to budgeting facilitates cooperation between programs to meet teaching needs, thus allowing the College to better utilize existing faculty resources. For example, a faculty member in one program can teach a course in his/her specialty area that may reside in another program or that may be interdisciplinary in nature.

CONCLUSION

For the last twelve years, Louisiana Tech University's College of Engineering and Science has operated under an innovative administrative structure which has created a supportive environment for numerous education reform initiatives. This flexible approach has significantly reduced or removed many of the barriers between engineering and science programs and promoted true collaboration. The momentum generated by these efforts has also led to

effective partnerships between the COES and other colleges within the university. Leveraging the advantages afforded by this unique approach, we have developed and implemented a number of innovative integrated educational programs which have attracted external funding, including $3.5 million in current NSF funding, in addition to many significant interdisciplinary research projects which have successfully secured millions in funding of their own. Consequently, this structure has enabled the COES to make significant strides in its vision to become the best in the world at integrating engineering and science in both education and research.

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