Interdisciplinary Engineering: Enabling Student Dreams, Broadening Participation in Engineering, and Increasing Student Retention

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Abstract - This paper presents the status of the Interdisciplinary Engineering (IDE) degree program at Missouri University of Science and Technology (Missouri S&T), formerly the University of Missouri-Rolla (UMR). The IDE degree was founded in 2005 at UMR to meet the emerging need to provide considerable flexibility to students allowing them to construct programs of study in areas of interest while maintaining a solid and rigorous foundation in mechanics, thermal science, electrical networks and linear systems. Students are able to pursue studying the latest technological fields through a collection of “tracks” enabled by the flexibility of the curriculum. This modern degree program houses energetic motivated students interested in a variety of disciplines from product design and amusement park fundamentals to industrial automation and control. The first students graduated the IDE program in December 2007. This facilitated the evaluation of IDE’s current status, preparation of its future plans, and sharing these findings with other universities interested in increasing student retention and broadening their demographic of engineering students. This paper presents statistics detailing the students involved in the IDE program, their educational interests inside the program (i.e. track selection), IDE’s budding reputation with potential students as well as its recognition in corporate America and its plans to broaden the popularity of the program. Lessons learned from the curriculum development and implementation will be discussed.

Index Terms – engineering curriculum, engineering design

INTRODUCTION

In this paper we report on the status of an innovative type of engineering department at the Missouri University of Science and Technology (Missouri S&T) that offers programs carefully designed to augment traditional engineering and science disciplines while providing the keystone engineering design and systems skills to create the engineers needed today. This engineering department, called Interdisciplinary Engineering (IDE), was founded in 2005 to produce graduates who are experts in the process of designing engineering systems. Moreover, the IDE degree provides considerable flexibility to students, allowing them to construct programs of study in areas of interest while maintaining a solid and rigorous foundation in mechanics, thermal science, electrical networks and linear systems.

In a previous publication about the initiation of the program ([1]), the authors proposed that IDE would assist the university mission by improving four key areas: 1) recruiting and retention, 2) adaptation to emerging technologies and the needs of local industry, 3) incubation of new degree programs, and 4) catalyst for interdisciplinary work.

This paper presents statistics addressing these four key areas as well as statistics detailing the students involved in the IDE program, their educational interests inside the program (i.e. track selection), IDE’s budding reputation with potential students as well as its recognition in corporate America and its plans to broaden the popularity of the program. Lessons learned from the curriculum development and implementation will be discussed. The future outlook for the IDE program is also mentioned with its focus on industrial marketing of the degree.

IDE BACKGROUND

The IDE degree was founded in 2005 at University of Missouri-Rolla (UMR), Missouri S&T, to meet the emerging need to provide considerable flexibility to students allowing them to construct programs of study in areas of interest while maintaining a solid and rigorous foundation in mechanics, thermal science, electrical networks and linear systems[1]. The unique curriculum of the IDE department allows for 7 engineering or science electives to be used toward the undergraduate degree.

The IDE department prepares graduates to use modern design methodologies, simulation, analysis, and optimization techniques within a team-based learning environment to develop safe and functional solutions to complex interdisciplinary design problems (i.e., systems) while adhering to systems constraints involving economics, reliability, durability, aesthetics, ethics, and social impact (including legal and environmental issues).

An NSF planning grant (EEC-0230088) supported the creation of this new curriculum. As part of the grant, the IDE curriculum was shaped through completion of seven tasks: 1) customer needs were gathered, where our customers consisted of potential students and potential employers of IDE graduates; 2) related programs and approaches were surveyed (e.g., [2, 3]); 3) ABET
requirements for the proposed degree were studied; 4) specialty track guidelines and defined sample tracks were formulated; 5) modern design methods were employed to link customer needs to a desired curriculum; 6) educational software available to support the IDE program was investigated; and 7) the proposed IDE curriculum was reviewed by three external experts [4].

IDE CURRICULUM AND CURRENT STUDENT STATUS

The Interdisciplinary Engineering (IDE) department and its curriculum provide an opportunity for students and faculty to create a distinct culture, community and identity. By fostering interdisciplinary studies, it will be inherently agile and adaptive, giving students the flexibility to choose – and even design – interdisciplinary specialties that match their interests and motivation.

The curriculum will lead to an Accreditation Board for Engineering and Technology (ABET) accredited Bachelor of Science degree in Interdisciplinary Design Engineering. The foundation of the curriculum is laid in the first two years with math, science, general education, and engineering fundamentals courses. Three IDE courses in the design area tie these foundational courses together in both the freshman and sophomore year. In the junior and senior years, the focus of the curriculum shifts toward design, engineering systems, and specialty track courses. Also, several general education electives, including two free (in terms of discipline) electives, are included.

Since the inception of the department in 2005 the number of specialty “tracks compiled and offered in the department has grown from four to fourteen. The growth in tracks is a reflection of student requests for fields of study, industrial requests, and faculty research interests. The fourteen available tracks are as follows: Acoustic and Electronic Systems, Amusement Park Fundamentals, Biomedical Design, Brewing Science, Disaster Management, Energy Systems and the Environment, Entertainment Engineering, Environmental (Green) Design, Forensic Engineering, Industrial Automation and Control, Nuclear Power Generation and Distribution, Product Design, Reliability Engineering, and Robotics and Control.

The IDE department currently has 24 students. The class standing of the students is depicted in Figure 1. Looking at the plotted information, it appears that interest in the IDE program dropped with the sophomore class. However, this number does not represent the students who have sophomore status and completed the IDE introductory course (IDE 105 Design Representations) their sophomore year. Figure 2 shows the enrollment trends for IDE 105. This plot captures the missing students and shows that the interest in the IDE program is increasing.

The specialty tracks selections of the IDE students is shown in Figure 3. From the plot it is clear that IDE is truly a home for aspiring engineers who have yet to choose a specific engineering discipline as their focus with 10 students who haven’t selected a track. Of those students who have chosen a track, product design is the most popular with four students, while tracks of student design are next.

The first two graduates of the IDE degree completed their program in December 2007 with three more following in May and August 2008. The ABET accreditation process was initiated with the milestone of the departments first two graduates. The departmental evaluation for accreditation will begin in the summer of 2008.
The introduction of the IDE degree in 2005 expected to impact four key university areas: 1) recruiting and retention, 2) adaptation to emerging technologies and the needs of local industry, 3) incubation of new degree programs, and 4) catalyst for interdisciplinary work. The original expectation of each of these areas are reviewed and statistics relating to the status of each area is presented.

**Goal - recruiting and retention:** Students in Interdisciplinary Design Engineering have significant flexibility in choosing interdisciplinary tracks of study. This opportunity appeals to some progressive and broad-minded high school graduates today who may perceive existing engineering departments as too confining. Students already in college who begin in a traditional engineering department and discover that their interests are broad may also find a home in IDE rather than abandoning engineering.[1]

**Current statistics – recruiting and retention:** 10 of the departments 26 total students transferred to the program from other academic departments (with the exclusion of the freshman engineering program). These retention numbers are encouraging and indicative that IDE offers a home to technically competent aspiring engineers who may have left the university without a flexible engineering option.

**Goal - ability to adapt to emerging technologies and the needs of local industry:** Many new companies, the ones driving the growth in the nation's economy, are creating and utilizing technologies that exist at the intersection of traditional disciplines. Most design projects in industry are now inherently cross-disciplinary, suggesting that extensive training in such an approach is vital. The kinds of technical personnel they need do not easily ‘fit’ in a single discipline. It is much easier for an agile, interdisciplinary department to offer specialized emphasis areas to meet particular industrial needs.[1]

**Current statistics – ability to adapt to emerging technologies and the needs of local industry:** It is quite evident that renewable energy is an increasingly popular emerging technology area. The unique structure of the IDE program has enabled it to explore green technology with new team taught courses and projects sponsored by local industry. January of 2008 saw the introduction of a Renewable Power Systems Design course, IDE 301. This course introduces students to a systems level analysis and evaluation of photovoltaic systems, flat plate collectors, geothermal power, and wind power. The concepts in the course are brought together by design projects. One of the projects tackled this semester are the design of a modular Solar Thermal Electric Panel (STEP) hybrid roof system to be installed on the Missouri S&T 2009 Solar Decathlon house. The other project is to propose a suite of commercial off the shelf renewable power systems to be installed on the Bond Clinic, a local medical facility, to reduce its energy costs.

**Goal - ability to incubate new degree programs:** Engineering deans can use a department like this to pilot or incubate a potential new degree program that will eventually become housed in its own stand-alone department. For example, on our campus, the faculty of the chemical engineering department is facing several challenges in defining and starting a biological engineering program. Such a program could be incubated within an IDE program where the more flexible curriculum would allow different course tracks to be tested before defining a permanent program.[1]

**Current statistics - ability to incubate new degree programs:** IDE is leveraging its faculty resources in failure analysis and materials testing together with forensic engineering consultants to offer a suite of Forensic Engineering specialty tracks. IDE together with the proposed collection of forensic engineering tracks has the capability to capture the potential student market opened by today’s TV programs and fill the industrial void of forensic engineers. The potential undergraduate forensic engineering program is using the flexible IDE curriculum to their advantage and testing the success of various course combinations with an active student pool. Moreover, the core courses of the IDE department have a strong systems focus, which is critical for forensic scientists, as accidents and crimes rarely occur as isolated stand-alone events. This incubation period will provide the information necessary to seek funding for the new degree program without the initial financial and resource risk of blindly initiating a bachelors forensic program on its own.

**Goal - meeting ground, a catalyst, for interdisciplinary work:** A department like this at its core will be interdisciplinary; it will depend on other departments. It will also provide a meeting ground and be a vehicle to foster communication and collaboration between engineering colleagues in different departments. This department will feed students into the classes of the traditional programs. Faculty from traditional programs will help create the needed interdisciplinary tracks. Senior design projects will be shared with existing departments and joint research will be pursued.[1]

**Current Statistics - meeting ground, a catalyst, for interdisciplinary work:** With energy conservation on the forefront of the news media, interest in developing a cross campus sustainability program has sparked. A Missouri S&T campus committee led by the Director of the Energy Research and Development Center formed to institute an engineering program wide Minor in Sustainability. The four course minor in development currently proposes to include two required courses, both to be housed in the IDE department. One will be a seminar course in sustainability and the other will be a capstone like course that will feature a design for sustainability project.

**The Future of IDE**

The future looks bright for the IDE program as student enrollment in the program increases as predicted. Further both a MS and PhD program in IDE have been approved on the Missouri S&T campus and are waiting for approval at the University of Missouri system level. The success of the
IDE program is leading to increasing the number of its tenure track faculty members. Four tenure track faculty have been hired since the program’s inception and several more are planned in the near future.

A key role for the department now is marketing to industry. The focus on marketing has driven the creation of a departmental committee with that aim. The committee is actively forming an industrial board, inviting departmental seminars from industry professionals, and exhibiting departmental projects and information at relevant industrial conferences such as the Institute of Industrial Engineers and the World Future Conference.

To enhance our marketing capabilities and physical facilities, IDE recently opened its doors to a new state-of-the-art Media Laboratory. It not only provides technical support for the IDE media campaign, it also serves as an inviting physical space that is indicative of our modern style approach to the future of engineering careers. The medial lab supports the vision of a new kind of engineering department involves not only a new curriculum and fresh approaches to teaching and learning, but also the creation of physical spaces that make a statement that this is a special, creative, dynamic, welcoming place for students and faculty to learn and interact. Continuing with the physical embodiment of IDE, the summer of 2008 will begin a season of physical renovation within the department. As previously publicized, “We envision brightly colored rooms, design projects on display – even hanging from ceilings – artwork, comfortable and stylish chairs and furniture, student and faculty commons area(s), music where appropriate, availability of scratch pads, dry boards and writing implements for impromptu brainstorming, cutting edge computer labs, wireless networks and laptops, classrooms set up to accommodate team activities, and many other special features...We seek to create a departmental culture where creativity is sparked, developed, and released as much as possible.” [1]

REFERENCES


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