QUALITY ENHANCEMENT OF GRADUATES FROM THE SCHOOL OF ENGINEERING AT SOUTHERN ILLINOIS UNIVERSITY-EDWARDSVILLE

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1. BACKGROUND

The School of Engineering at Southern Illinois University-Edwardsville comprises six engineering programs (civil, computer, electrical, industrial, mechanical, and manufacturing), computer science and construction programs. With the exception of manufacturing engineering which is the newest addition to the school, all the programs are ABET accredited. In recognition and pursuit of one of the key mission statements of the School of Engineering (SOE), the time to undertake and establish a school-wide quality enhancement of all our graduates cannot be better than now for the following reasons:

1. Our school has been experiencing a steady enrollment growth of better than 10% annually for the past three years,
2. With constrained resources and increasing enrollment trend, quality enhancement of our programs can serve as one of several possible actions upon which to optimize the value of our educational programs,
3. Enhancement of our program quality will attract better students resulting in a sense of pride for our graduates,
4. Our graduates are the great ambassadors for our programs. Their professional accomplishments are reflections on our institution in general and on our programs in particular,
5. Our proclaimed niche of providing excellent undergraduate engineering education in the region/state needs to be supported and strengthened with demonstrated and holistic commitment at all levels, and finally
6. Quality breeds recognition and recognition translates into good reputation.

One of the key elements of our strategic plan is to provide excellent undergraduate engineering education in the region/state. Excellence, by all accounts, is indicative of high quality end products (graduates). Given the prevailing conditions of limited resources at all levels of support and in tandem with increasing enrollment trend over the past few years, our proclaimed niche incidentally becomes prone to potential setbacks and therefore demands a rational solution.

In formulating a procedure to meet the expressed need of enhancing the quality of our graduates, we characterize the solution scheme as a three-phase affirmation of acceptance to undertake the challenge, identify some educational quality indicators as basis for measurement, and proceed to examine a four-year degree program in engineering as a production system for the purpose of achieving quality enhancement of our graduates. Based on the production system analogy, the process of enhancing the quality of our finished product (graduate) requires the identification of the bottleneck operation or process during the course of the four-year period.

2. GRADUATE QUALITY ENHANCEMENT

Product quality may be enhanced during three broad stages of production: raw material acceptance; processing; and final test reject/acceptance. This realization leads, in an educational environment, to the identification of three academic levels at which efforts may be made to enhance SOE quality in terms of the school's primary product - graduates. These levels are:

2.1 Admissions

The raw material, in terms of the production of graduates, is the incoming student. The academic analog of the raw material acceptance standard is the set of admission criteria. Three major courses of action are available to the SOE in this regard:

a. **An enhancement of the admission requirements for new freshmen:** This option would affect the entire campus, and as a result, may not be feasible in the short term.

b. **An enhancement of the requirements for admission to SOE programs:** This alternative is more easily accomplished, and may be desirable. In addition to existing requirements, admitted SIUE students interested in engineering should have satisfied the following requirements before declaring engineering as major:

   (i) At least three years of high school math including college algebra or equivalent,
   (ii) At least three years of high school science including physics and/or chemistry or equivalent.

   These basic requirements are consistent with IBHE minimum college planning requirements specified for high school students in the State of Illinois.

c. **An enhancement of the requirements for admission to upper division standing in the School of Engineering:** The following proposed requirements for enrollment in upper division engineering courses should be consistent and applicable to all engineering disciplines:
   (i) An approved application for enrollment in upper division engineering courses [this is currently the case in some programs but it needs better enforcement]
   (ii) Satisfactory completion of the lower-division (core) courses: [to be specified by each discipline] with a grade point average of at least 2.25 for the

specified courses; 2.25 for equivalent courses for transfer students from articulated programs, and Illinois resident transfer students; a grade point average of at least 2.50 for the equivalent courses should be required for other transfer students,

(iii) A prerequisite can be fulfilled only by a grade of C or better. A grade of D is sufficient to pass a course but not sufficient to qualify the student to enroll in a more advanced course that list the former as a prerequisite,

(iv) A grade of C or better should be required in certain pre-engineering courses that are essential to the specific disciplines, for instance:

1. *ME 262, CE 240, CE 242, etc. for mechanical engineering,*
2. *CE 240, CE 242, ME 262, etc. for civil engineering,*
3. *ECE 210, etc. for electrical and computer engineering,*
4. *CE 240, CE 242, etc. for industrial and manufacturing engineering*

2.2 Academic Practices

This extremely broad category encompasses the entire SOE "production process". It is analogous to the production process in an industrial system. A large number of practices exist which may be targeted for enhancement in this category. These practices include curriculum design issues, student advising, facilities, faculty, and student support.

2.2.1 Curriculum Design Issues: Design of the program starts with the recognition of engineering education components: (mathematics/basic sciences, engineering sciences, upper division courses or discipline-specific courses and skills/general education courses). Specific characteristics should be identified within each specialty area and classify as categories of discipline responsibilities.

Figure 1 shows the product flow (student progression) through our educational system. This is analogous to an assembly line production with incoming raw materials (freshmen students), eventually become transformed into work-in-process (returning students) over a period of four years for continuous product/process refinement before emerging as finished product (engineering graduates).

One segment of the engineering curriculum that has the greatest potential for quality enhancement is the pre-engineering or lower-division phase, because it constitutes the bottleneck in the system. A student with good grasp of the fundamental math, basic science, and engineering science principles can be assured of being capable to go into any engineering discipline of his/her choice and be successful. In order to encourage and push interdisciplinary engineering education, we have to recognize the need for a fundamental skill set in our curriculum design. This premise begs for the following questions:

- What constitutes the core essence of engineering education?
- What should every engineer know as part of his/her skill set to appreciate the essentials of engineering profession?

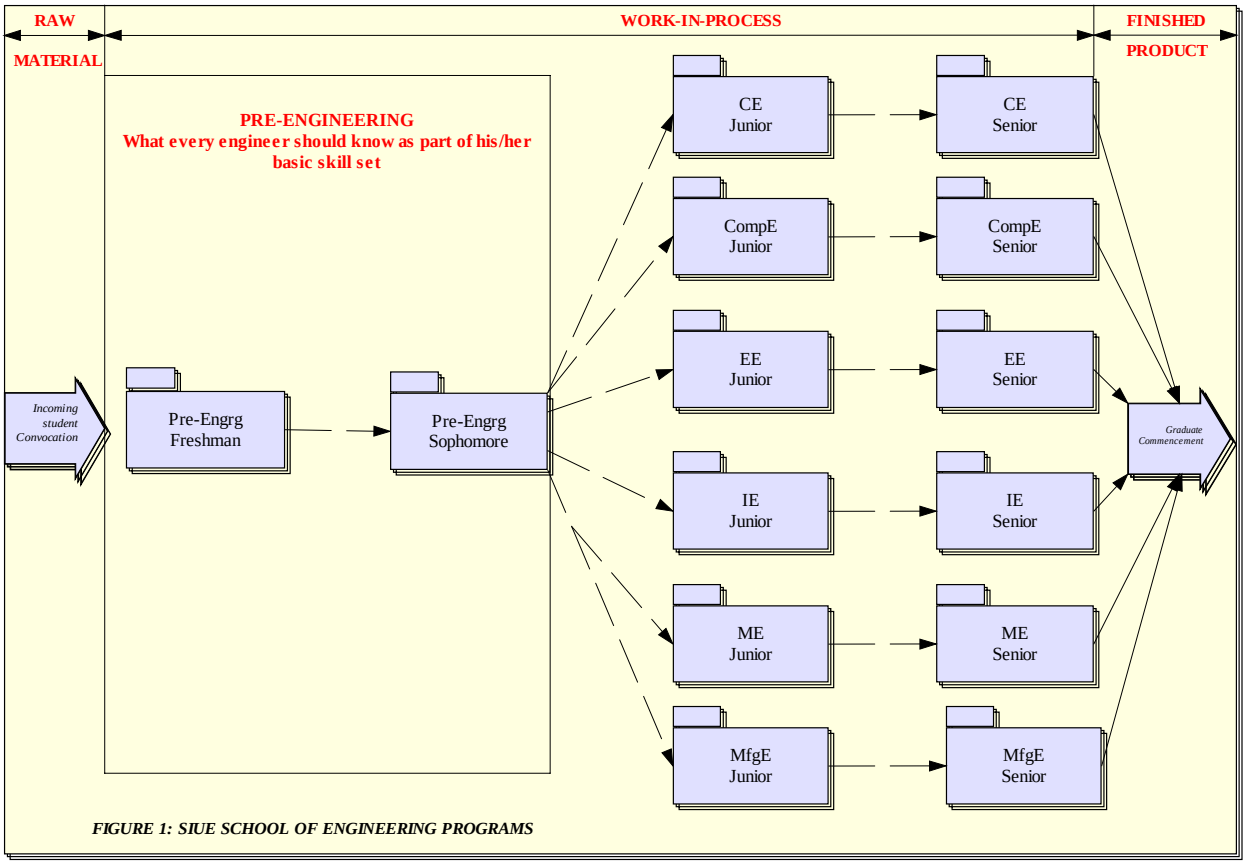

Figure 1: SIUE School of Engineering Programs

Mindful of the common attributes and unique perspectives of the various engineering disciplines, we are inclined to propose that a taskforce made up of a faculty member from each discipline be setup to examine the merit of the two questions raised above and all other issues pertaining to this matter of graduate quality enhancement.

2.2.2 Student Advising Practices: There is a general expectation among faculty that with our published curriculum guide students should not have difficulty knowing what courses to take. We sometimes forget to realize that most of our students are coming into the programs with different levels of skills and background. Building upon the existing practices for undergraduate student advising, some recommendations were passed on to the taskforce for further review.

2.2.3 Lab and Computing Facilities: Laboratory and computing facilities play a significant role in the delivery of quality engineering education. They are intended to provide supporting environments that greatly enhance teaching methods and effectiveness of engineering faculty. The quality of a student skills acquisition is practically enhanced with the opportunity to perform hands-on laboratory experiments and/or exercises.

As a practical field of study, engineering fundamentally requires huge capital investment in machines, equipment, special tools and technicians for the purpose of equipping the laboratories.

Furthermore, acquisition of these machines requires mechanisms for upkeep and routine maintenance in order to provide continuing support of our educational mission.

2.2.4 Faculty: The role of faculty members in the re-engineering of quality engineering education cannot be over-emphasized. As part of the emerging vision for the school, faculty members have the mandate from the governing body of the school to actively engage in

- effective teaching methods resulting in quality instruction/grading,
- maintaining high academic standards that do not compromise the essence of the profession for expediency.

Specifically, junior faculty members should be encouraged not to feel pressured for good course evaluations at the expense of maintaining academic standards. The greatest achievements of the 20th century are primarily engineering feats, such as electrification, highways, telephone, radio/television, automobile, airplane, spacecraft, water supply and distribution, computers/internet, household appliances, etc. Mediocre engineers devoid of intellectual curiosity did not accomplish these achievements. How many times have we wondered if we have let a student to slip through the crack and graduate when in fact the student does not deserve nor merit the new status of being an engineering graduate? We are the gatekeepers of our great profession. Let us not abdicate our responsibility for whatever reasons.

2.2.5 Student Support: One of the most pressing issues is that of student support. A large proportion of SIUE Engineering students hold part time, off-campus jobs. Students who do not have access to adequate financial resources at the lower and upper division levels are forced to contend with a number of disadvantages. Chief among these is reduced time-on-task, resulting from the necessity to engage in employment that is in no way related to the career which the student hopes to pursue. In fact, it has been shown that these financial considerations often prevent initial entry into the educational paths which lead to technical careers.

It is not possible to change the financial situation of all SOE students. It is, however, possible to seek external funding which may be used to provide some percentage of SOE students with engineering-related part time employment *on-campus*.

2.3 Exit Requirements

This category of opportunity is analogous to the final test/acceptance/reject of product. It is not desirable to reject students at this level. However, information may be gathered just prior to student program exit which could provide invaluable feedback for the School of Engineering. One major mechanism through which this feedback may be obtained is the Fundamentals of Engineering Examination. In addition to the current exit requirements, we will like to propose the following recommendation:

- *Each engineering program should require students to take (not pass) the FE exam as a graduation requirement. The administering agency for this examination provides summary reports to institutions whose students take the FE in large*

numbers. Other discipline specific examinations (e.g., the Certified Manufacturing Technologist Examination) provide similar, but more specific feedback.

- *A grade of C or better should be required in certain upper-division courses that are essential to the specific disciplines,*
- *A minimum cumulative GPA of 2.25 (on a 4.0 scale) for graduation.*

As an example of how change can be initiated from the bottom-up at SIUE, the following quote from one of the faculty members regarding the "quantitative literacy" discussions on the list-serve also adds credence to the FE exam requirements:

> *"Some Chemistry faculty choose to give the Standard American Chemical Society exam as an EXIT exam, and scores on this exam correlate well with the assigned "letter" grade. This is reality check to balance the (local? National?) trend towards grade inflation. Students with a "C" or better in CHEM 121a have achieved a measurable level of aptitude in Chemistry, and can be confident that they are adequately prepared for courses for which CHEM 121a is required."* [**Eric J. Voss, Associate Professor of Chemistry, September 2003**]

3. CONCLUSION

We have examined a four-year degree program in engineering as a production system. Based on that analogy, the process of enhancing the quality of our finished product (graduate) requires the identification of the bottleneck operation or process during the course of the four-year period. The pre-engineering phase of the engineering curriculum is identified as the bottleneck process and therefore presents the greatest opportunity for quality enhancement of our work-in-process entities (students). Given our limited resources, any enhancement effort that fails to take into consideration the identified bottleneck will yield marginal benefits. Faculty's role in supporting our students to learn what they don't know and cause them to be curious intellectually should be encouraged as a byproduct of their teaching effectiveness.

According to Bill Wulf (President of the National Academy of Engineering), "*Engineering over the past century has had more impact on human life than any other profession. Clean water and sanitary sewers, for example, have done more to increase our lifespan than all of medicine put together*." Today, new technology is affecting how professors teach and how students interact with them, and one another, both inside and outside the classroom. Industry, facing intense pressure from competitors around the world, is demanding engineers who have traditional technical expertise but who also have design experience and can work in teams, communicate ideas effectively, and perform in cultures other than their own and with colleagues different from themselves.

As the gatekeepers of our great profession, we (faculty) are expected to engage in maintaining high academic standards that do not compromise the essence of the profession for expediency. Though the study focused primarily on engineering programs, because of its unique structure, the underlying processes, principles, and some of the proposed recommendations would equally be applicable to other programs housed within the school/college of engineering such as computer science and construction programs.