

## **Educating Future Engineers: An Example**

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### **Abstract**

Engineering education in the United States is going through a change, much of it driven by two recent reports from The National Academy of Engineering and the internationalization of the profession. This is a normal process of evolution in the education of future engineers to make them better prepared to be effective professionals in the environment they will face. As part of this evolution and the normal process of quality improvement, Wichita State University has recently launched a strategic initiative, *Engineer of 2020*. This paper reviews the background and the rationale for this initiative as well the implementation of it. Also discussed is the experience to date.

### **Keywords**

Engineering education, Engineer of 2020, Service Learning, Global Learning

### **1. Introduction and Background**

One of the challenges and responsibilities of the educators in a professional discipline like engineering is to ensure the relevance of its curricula. As a result, in the US, engineering faculty review and reorient their curricula on a regular basis. This review takes place because of internal and external considerations. External considerations include feedback from program graduates and employers, changes in government regulations, employment trends and related statistics, changes in the profession, etc.

The recent impetus for curriculum changes has been two reports published by the National Academy of Engineering, a private, independent organization set up by the US Congress with the mission “to promote the technological welfare of the nation by marshaling the knowledge and insights of eminent members of the engineering profession.” [1]. The first report, *The Engineer of 2020: Visions of Engineering in the New Century* [2], asserts that “To maintain the nation’s economic competitiveness and improve the quality of life for people around the world, engineering educators and curriculum developers must anticipate dramatic changes in engineering practice and adapt their programs accordingly.” It identifies “the ideal attributes of the engineer of 2020, the report recommends ways to improve the training of engineers to prepare them for addressing the complex technical, social, and ethical questions raised by emerging technologies.” The second report, *Educating the Engineer of 2020* [3], “offers recommendations on how to enrich and broaden engineering education so graduates are better prepared to work in a constantly changing global economy. It notes the importance of improving recruitment and retention of students and making the learning experience more meaningful to them. It also discusses the value of considering changes in engineering education in the broader context of enhancing the status of the engineering profession and improving the public understanding of engineering.”

The Engineering of 2020 [2] report is framed by the following guiding principles:

1. “The pace of technological innovation will continue to be rapid (most likely accelerating).
2. The world in which technology will be deployed will be intensely globally interconnected.

3. The population of individuals who are involved with or affected by technology (e.g., designers, manufacturers, distributors, users) will be increasingly diverse and multidisciplinary.
4. Social, cultural, political, and economic forces will continue to shape and affect the success of technological innovation.
5. The presence of technology in our everyday lives will be seamless, transparent, and more significant than ever”.

It also indicates that future engineering graduates will be those who: [2]

1. “Will possess strong analytical skills
2. Will exhibit practical ingenuity
3. Be creative
4. Have good communication skills
5. Have mastered the principles of business and management
6. Understand the principles of leadership and be able to practice them
7. Possess high ethical standards and a strong sense of professionalism
8. Possess dynamism, agility, resilience, and flexibility
9. Be life long learners”

Others have also identified similar characteristics of future engineers. For example, 2007 Engineering Outlook [4] indicates that “The traditional skills of an engineer (math & science) are still paramount to a successful career in engineering, but a shift towards stronger ‘soft skills’ is a notable trend. Employers are seeking employees with strong communication skills, leadership qualities, creativity, and an ability to function within a team.” Rugarcia et al. [5] identified these seven features that will pose challenge to future engineers:

1. “Information - proliferating
2. Technological development – multidisciplinary
3. Markets – globalized
4. The environment – endangered
5. Social responsibility – emerging
6. Corporate structures – participatory
7. Change – rapid”

The rest of the paper is organized as follows: section 2 describes the strategic initiative implemented at Wichita State University for educating the future engineers; section 3 provides a summary of the early results of the implementation since fall 2007 and the lessons learned; and, section 4 provides a few concluding remarks.

## **2. Wichita State University’s Strategic Initiative – Educating the Engineer of 2020**

Whitman, Toro-Ramos, and Skinner [6] provide a description of the strategic initiative by the College of Engineering at Wichita State University in response to these challenges. The motivation of this initiative is to “establish (the college’s) leadership in reshaping the undergraduate experience to prepare the engineer of 2020, and at the same time make the educational experience more meaningful to the student and the student more desirable to local and national industries.” The following description of this initiative is largely copies of relevant materials from this paper [6].

The initiative proposes that “to fulfill the requirements for an Engineering BS degree at WSU, each student will complete the (engineering) program course requirements including at least three of the following six activities:

1. Undergraduate Research
2. Cooperative Education or Internship
3. Global Learning or Study Abroad
4. Service Learning
5. Leadership
6. 6. Multidisciplinary Education”

Following are brief definitions of each activity and a summary of how the student may fulfill the requirements of the activity.

- Undergraduate research: Students work under the supervision of a faculty member either as an undergraduate research assistant for one semester or perform an independent study. The faculty supervising

the undergraduate research approves the activity and signs a form. To satisfy the Undergraduate Research criteria each student must complete one of the following:

- i. One full semester as an undergraduate research assistant to a faculty
  - ii. independent study, under the guidance of a faculty member, performing a comprehensive and critical literature review of an emerging area of research (analysis/synthesis of the current state of knowledge in that area).
- Cooperative Education/Internship: To satisfy the Cooperative Education or Internship criteria each student must complete one of four tracks available: Cooperative Education, Internship, Combination, or Industrial Experience.
    - i. Cooperative Education Track - To successfully complete the internship track, students will complete two semesters of full-time or four semesters of half-time cooperative education work sessions; enroll in one credit hour of cooperative education during each of the semesters; earn two to four hours of cooperative education credit that count toward their technical elective requirement. A cooperative education endorsement will be noted on a student's transcript if the university records satisfactory performance during all work sessions and the student meets all cooperative education requirements.
    - ii. Internship Track - To successfully complete the internship track, students will complete at minimum two semester-long internships; enroll in one credit hour of internship credit during each of the two semesters; and, earn two hours of internship credit to count toward their technical elective requirement. An internship endorsement will be noted on a student's transcript if the university records satisfactory performance during the two work sessions and the student meets all of the internship requirements.
    - iii. Combination Track - Some students desire the opportunity to have a variety of work experiences. The Combination Track will address these students' needs. To successfully complete the combination track, students will complete at minimum two semesters of cooperative education work sessions and a one-semester internship; enroll in cooperative education /internship course during each semester of work experience; earn three hours of internship credit to count toward their technical elective requirement. An endorsement will be noted on a student's transcript if the University records satisfactory performance during the work sessions and the student meets all of the cooperative education/internship requirements.
    - iv. Industrial Experience Track - Some students work with employers who have yet to form a cooperative education or internship agreement with WSU. The Industrial Experience Track provides these students a means by which to validate their industrial experience as fulfilling the cooperative education and internship criteria. A valid work experience will involve the application of engineering principles and must be approved by the student's academic department. This track does not provide academic credit hours toward degree. To successfully complete this track, students will submit a proposal, that identifies the work experience, to their academic department for approval; complete at minimum two semester-long (full time) or four semester-long (part time) approved work experience; summer counts as a semester.
  - Global Learning: To satisfy the Global Learning or Study Abroad criteria each student must complete one or more of the following:
    - i. Successfully participate in a global learning project within an existing class; this will typically involve internet-based communications with students, teachers, and colleagues in at least one other country. Global learning projects must include at least one participant from outside the English-as-a-first-language world (e.g. Russia, Japan, China) to be eligible.
    - ii. Successfully complete a study abroad component; this involves participating in a credit-bearing, university-approved study abroad activity in a foreign country. (Note: Students possessing an F-1 VISA qualify for this criteria and must submit a form to the Director of Engineering Education.)
    - iii. Submit a previous global learning or study abroad experience; in this case, the student must prepare a two-page report outlining: Summary of previous experience, including dates and

locations; description of the student experience (typically a reflective paper, though not restricted to this); and contact information of faculty/sponsors involved in the global learning experience

- **Service Learning:** To satisfy the curricular requirements of Service Learning, each student will complete one of the following:
  - i. A project that meets the criteria of service learning as a significant component of a one-semester, for-credit existing course.
  - ii. A one-semester, for-credit Independent Study course that meets the criteria of service learning. Each student will enroll in the Independent Study course of their major, and will work in multidisciplinary, cross-College teams.
  
- **Leadership:** To satisfy the Leadership criteria each student must:
  - i. Take some formal instruction on leadership
  - ii. Propose and demonstrate a leadership experience
  - iii. Submit a short report on the experience.Leadership instruction is necessary in order for the student to gain the skills necessary to be an effective leader. If a student had already demonstrated leadership in some role or activity and submitted a report documenting the experience, then this requirement could be waived. The course/workshop should have the following objectives: Students will be able to-
  - ✓ Demonstrate the ability to communicate leadership knowledge verbally and in writing.
  - ✓ Critically examine, explore, and evaluate the usefulness of leadership concepts.
  - ✓ Demonstrate effective team leadership skills.
  - ✓ Regularly assess one's knowledge base and skills, and seek additional information to build leadership capability.
  - ✓ Recognize and value the role of life-long learning, self-assessment, and critical thinking in leadership development.
  
- **Multi-Disciplinary Education:** Students obtain a minor or second major outside their engineering discipline. The student submits a form to the Director of Engineering Education documenting completion of this criterion. Students are multi-disciplinary if they grow academically in areas outside their engineering majors. To satisfy the multi-disciplinary experience, each student will obtain a minor or second major.

### **3. Results of Implementation/Lessons Learned**

As the program has only been officially in place since Fall of 2007, the full implementation results are not yet complete. However, progress so far has made evident a few key points: students see program value, students choose as opportunities arise and marketing and advising are crucial.

#### **3.1 Students See Program Value**

Typically when students are required to change, the students resist the change. Especially, when there are additional requirements on the students. However, with the Engineer of 2020 program, little resistance has been observed. This may be due to student perceived value of the program or due to lack of knowledge of the program and its impact on their graduation. As previously mentioned, students who start in the Fall of 2007 are required to complete the program. However, students who matriculated prior to the Fall of 2007 are not required to complete the program. Several students who matriculated before Fall of 2007 are participating in the program and completing the requirements. Students who are required to complete the program are making progress.

#### **3.2 Students Choose as Opportunities Arise**

Students typically do not plan much in advance. As opportunities present themselves, students will alter their plans to take advantage of opportunities that previously were unavailable. As an example, when the economy was good, most students expected to complete the cooperative education or internship criteria. That was when most students with a reasonable grade point average could obtain a position. Now these positions are more difficult to find. On the other hand, few students viewed themselves as completing a global learning or study abroad criteria. With the emergence of the Global Design Challenge (GDC) now available to students, more students consider the global component a viable option. For more details about the GDC, please refer to Whitman et al. [7].

### 3.2 Marketing and Advising are Crucial

Many students are not good agents of their academic progress. Students are frequently unaware of requirements to complete their degree. Therefore, in implementing a new program, student awareness is vital to its success. In addition to student awareness, student advisors and enrollment staff must also be made aware of requirements and opportunities. General sessions with students, brochures and training for advisors and staff is required. The more students hear and see a program, the more aware they are of its existence. The more they are aware of it, the more they begin to understand its impact on their future. As previously mentioned, students begin to see the advantage of such a program and how it can positively impact their career. Presented as a benefit instead of a burden, students (and advisors) appreciate the program and strive to find new avenues for its success.

### 4. Concluding Remarks

With rapid changes in technology and the globalization of manufacturing and supply-chain, it is imperative that engineering curricula remain current. This continuous process of curricula revision, in reaction to as well as in anticipation of changes in the environment of practice and the development of new knowledge, must be conducted in a regular fashion. Several recent studies have identified the characteristics of new engineers and the content of an engineering curriculum. In response to these, the College of Engineering at Wichita State University has developed the *Engineer 2020* initiative. Under this initiative, students are to participate in three out of the following six identified activities: undergraduate research, cooperative education or internship, global learning or study abroad, service learning, leadership, and multidisciplinary education. This paper highlights this initiative, which has been implemented beginning with Fall 2007, in more details. We have also described some of the early results and identified some lessons learned.

### References

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