2006-2021: NEW CURRICULUM IN INDUSTRIAL ENGINEERING

M. Jeya Chandra, Pennsylvania State University

Richard Koubek, Pennsylvania State University

Dr. Richard J. Koubek is Professor and Head for the Harold and Inge Marcus Department of Industrial and Manufacturing Engineering at The Pennsylvania State University. Prior to this appointment he held the posts of Professor and Chair for the Department of Biomedical, Industrial and Human Factors Engineering, and Associate Dean for Research and Graduate Studies for the College of Engineering and Computer Science at Wright State University. He served six years on the faculty in the School of Industrial Engineering at Purdue University and began his academic career as a faculty member in the College of Engineering and Computer Science at Wright State University. Dr Koubek's research focuses on usability, human aspects of manufacturing, and human-computer interaction. He has been editor of the International Journal of Cognitive Ergonomics, and is a member of the Editorial Board for the International Journal of Human Factors in Manufacturing and the International Journal of Human-Computer Interaction. Dr. Koubek was Conference Chair for the Fifth International Conference on Human Aspects of Advanced Manufacturing and Hybrid Automation and Co-Chair for the Fourth International Conference on Engineering Psychology and Cognitive Ergonomics. Dr. Koubek received his Ph.D. in Industrial Engineering from Purdue University.

THE NEW CURRICULUM IN INDUSTRIAL ENGINEERING AT THE PENNSYLVANIA STATE UNIVERSITY

Introduction

Even though the old curriculum in Industrial Engineering at Penn State University covers basic tools an industrial engineer should possess, broader applicability of these tools in areas such as service processes was not very well covered in this curriculum. Based on the feedback received from the current students and alumni, the department faculty decided to modify the curriculum so that students are provided with a broader domain of applicability and the objective of educating the world class Industrial Engineer is met. In addition, it was also decided to give the students, the option of specialization through tracks in the new curriculum. The emphasis of this curriculum is educating students on the principles, tools and techniques of the industrial engineering profession which can be applied to the tracks. The critical processes required to analyze and solve problems in the different areas and desirable outcomes are covered in courses.

The new curriculum will give the students, the option of selecting one of the following tracks which will prepare them well for the job market in industrial engineering.

- Manufacturing Systems Engineering
- Engineering Service Systems
- Engineering Information Systems

In endorsing the new curriculum, the department Industrial Professional Advisory Committee (IPAC) said: *"The IPAC group for the Industrial and Manufacturing Engineering department firmly endorses the curriculum changes being proposed by the department., These changes are a direct result of prior discussions and recommendations between the IPAC group and the faculty of the department, partially as an outcome of the prior strategic planning effort in the department initiated in 2001. The need for this reform has become more obvious over the past few years, and we feel that it is critical that the department institutes these changes to stay abreast with the continual shifts in industrial engineering practices, techniques, and applications. The breadth of the industrial engineering profession uniquely lends itself to a curriculum that offers more flexibility and choices to its students, as the new curriculum proposal offers. In addition, the additional emphasis on emerging fields within the service sector and in the information technology field will make our curriculum more appealing to potential students, and will enrich the education that Penn State IME students receive".*

This paper describes the curriculum and its objectives.

Basic approaches to curriculum change

- Integrate other applications areas (e.g., service processes) into existing courses.
- Reorganize required courses into areas of competency.
- Reorganize elective courses (IE and non-IE) into domain areas.

- Introduce elective course(s) in other application areas (e.g., service processes, financial engineering, health care management, etc.)
- Introduce a focused design project in various application domains.

Description of changes

Changes in the non-major courses from other departments in the College of Engineering

The old curriculum required that the students take the following non-major courses in the college.

a) Introduction to Engineering Design (ED &G 100) 3 Credits

b) Computer Programming for Engineers Using C or Computer Programming for Engineers using FORTRAN (CMPSC 101 C or F) 3 Credits

c) Statics & Strength of Materials (EMCH 210) 5 Credits

d) Dynamics (EMCH 12) 3 Credits

e) Introduction to Thermal Science or Engineering Thermodynamics I (ME 23 or 30) 3 Credits

f) Introduction to Digital Systems or Electrical Circuits & Power Distribution (CSE 271 or EE 220) 3 Credits

All these courses were required in the old curriculum, because of the College of Engineering policy that students in each major within the college should take a minimum number of courses from the other departments within the college. Since the college decided to waive this requirement, the curriculum committee wanted to keep only those courses which are prerequisites to the courses required in the major. As EMCH 12, ME 23 / 30 and CSE 271 / EE 220 (d, e and f above) are not prerequisites to any of the required courses, these nine credits are added to a non-major elective group from which students have to take six credits. Students who complete an approved minor can get three credits applicable to this group. Also, three credits in this group can be earned by the students who complete three semesters of co-op or internship or those who complete the ROTC program. In summary, the requirement in this group is as follows.

Any six credits out of the following**.**

CSE 271 or EE 220 (3)
E MCH 12 (3)
ME 23 or 30 (3)
Three credits for students who complete any approved minor
Three credits for any combination of Co-op or Internship
Three credits of ROTC upon completion of ROTC program.

This change resulted in a saving of three credits.

Addition of a three-credit required course in Information Technology for Industrial Engineers

This course will provide students with Information Technology background required to develop applications in Industrial Engineering. It covers an overview of Object-Oriented Programming, Enterprise Information Modeling, Analysis of Data Bases, Data Mining and Internet technologies. Specific application examples from industrial engineering, manufacturing and service areas will be discussed. The goal is that students understand and apply concepts of programming (using Java as a foundation) to solve engineering problems, including manufacturing and service related problems. The introduction of this new course (IE 330) added three credits to the new curriculum.

Changes in Probability / Statistics / Quality Control Area

In the old curriculum, the baccalaureate students had to take three courses (a total of nine credits) in probability, statistics and quality control. In the new curriculum, these three three-credit courses are condensed into two three-credit courses, by eliminating overlap, adjusting the time spent on some topics and introducing a new three-credit elective course covering some topics taught currently in the three courses and expanding them. This helped to reduce the total number of credits required for obtaining a baccalaureate degree in Industrial Engineering by three, at the same time covering the critical topics required for an Industrial Engineer in the required courses.

Changes in the Human Factors Area

In the old curriculum, two courses (a total of six credits) were offered in the human factors area, which were required for all the baccalaureate students in the department. The first course introduced a basic level of human factors/ergonomic design principles and work measurement tools. The second course covered the ergonomics principles for designing an efficient work place and cognitive work design. In addition, there were two senior level electives in this area – one focusing on the safety related issues in a work place and the other on the human-computer interface.

In the new curriculum, the existing first course (IE 327) has been modified by the addition of some ergonomic and cognitive tools to its list of topics. The second required course and the two senior electives in the current curriculum are modified into two courses in the new curriculum. The second course (IE 408) covers the design and evaluation of cognitive work, including the human/computer interface, visual displays, software design, and automated system monitoring, with emphasis on human performance. The third course (IE 419) focuses on methods improvement, ergonomic work design, productivity, work measurement, and safety principles for manual work. The baccalaureate students in the Department of Industrial and Manufacturing Engineering must take the first course and the second or third course as a required course. The students also have the option of using the second or third course, the course which

was not taken as the required course, as an elective. There is no change in the total number of credits (six) in this area.

Changes in the Manufacturing Area

In the old curriculum, there were four required courses (a total of twelve credits) in the manufacturing area. In the new curriculum, the total number of credits required in the manufacturing area has been reduced to nine credits (three courses). The first course (IE 305) in the sequence of three courses, helps students to acquire an overview of the design / manufacturing world and to learn how design and manufacturing engineers communicate and how products are represented. It is independent of manufacturing processes. Next, students have to take a course in a manufacturing process, such as metal cutting, metal casting or electronic assembly. The third course (IE 470) teaches how generic processes are organized, analyzed and managed for economic production of goods and services and is independent of the manufacturing processes. This change resulted in a decrease of three credits.

Changes in the Operations Research Area

The old curriculum required the students to take three operations research courses (nine credits) . The only changes made in these courses in the new curriculum are the elimination of overlap, better sequencing of topics and addition of some applications. The first course is Linear Programming (IE 405), in which students learn formulating and modeling of real life problems using linear programming. In the new curriculum, IE 405 is made a concurrent course to the second course, Introduction to Operations Research (IE 425), because the modeling which the students learn in IE 405 will be useful in IE 425 and some problems in IE 425 can be modeled using linear programming. The third course, Simulation Modeling (IE 453), covers simulation and is changed to include some applications of simulation. There is no change in the total number of credits (nine) in this area.

Changes in the Capstone Design Course

In the old curriculum, there were six design electives which satisfy the ABET requirements of a capstone design course. In the new curriculum, these are replaced by a one new capstone design course (IE 480), which will make it easier to satisfy all the ABET requirements and at the same time give the students valuable experience. Students will develop “real world” engineering project experience through industry-based projects in this course. Projects will focus on manufacturing systems, service systems, and/or information systems. This course will also be the “Writing-Intensive” (W) course in the new curriculum. There is no change in the total number of credits in this area.

Tracks

After completing the courses in core and fundamental competencies, students will choose one of the following tracks and take nine credits of courses from the approved list, out of which at least six credits must be from the department of industrial engineering.

Track in Manufacturing Systems Engineering

The old industrial engineering curriculum focused more on traditional manufacturing engineering. The role of manufacturing (materials processing) in the U.S. has changed and become more of assembly than materials processing. It is important that the industrial engineering students are provided with both breadth and depth knowledge of a variety of engineering principles related to product specification, product verification, materials, manufacturing processes and design and analysis of manufacturing processes and systems. This will equip them with the knowledge and skills necessary to handle the changes in the manufacturing sector. Hence, it was decided that one of the tracks should be Manufacturing Systems Engineering and that the courses in manufacturing be changed to reflect the needs of manufacturing industries.

Track in Engineering Service Systems

Historically industrial engineering problem solving tools have been applied mostly to something physical like a production line. But recently, the service sector has become very important in today's economy and a very large percentage of the working population is employed in the service sector. The problem solving tools which the students in industrial engineering learn can be applied to improvement of service industries also. Many major service industries suffer from low quality and productivity, which can be remedied by industrial engineers. Because of this need for industrial engineers in service sector, an advisory board of Industrial Engineering alumni recommended the creation of a track in Service Systems Engineering. In addition, applications of problem solving tools in service sector are included in required courses. In this track, students will acquire, refine and apply their industrial engineering tools and techniques within a service context. Instantiation and practice of this knowledge will be presented in a variety of arenas, emphasizing commonalities between manufacturing and service. For example, while work measurement and time study examples have traditionally been in the production environment, examples may include such areas as healthcare and telemarketing.

Track in Engineering Information Systems

Collection and processing of information have increased in all sectors for solving engineering problems, including manufacturing and service related problems. Efficient and timely analysis of data is critical for the survival of companies. There is a need for industrial engineers with a strong background in information technology and systems. This is the motivation for the track in Engineering Information Systems in the proposed curriculum. Similar to the track in Service Systems Engineering, the track in Engineering

Information Systems will also cover application of industrial engineering tools within an information systems context.

The addition of tracks increased the total number of credits by three. The net result of all these changes is the reduction of three credits in the total number of credits, bringing the total credits required for a baccalaureate degree in Industrial Engineering from Penn State to 129.

Case Studies

In addition to these changes, case studies involving applications from service sector are being introduced in appropriate courses. This is made possible because of assistance from the members of Service Advisory Board and funding from the Leonhard Center for the Enhancement of Engineering Education at Penn State. Some of the case studies developed and used in courses in the new curriculum are given below.

- fitting an appropriate probability distribution to the number of checks per transaction processed by a real estate management company, on behalf of its customers.
- graphical analysis of the average length of stay in a hospital and calculation of summary statistics.
- conducting a correlation analysis of the relative unit price and the resulting relative market share.

The introduction of these case studies is expected to expose the students to a wide range of applications of the industrial engineering tools.

Faculty Involvement in the Development of the New Curriculum

The faculty in the department have been concerned about the gradual decline of the manufacturing activity in the U.S. and were convinced of the need to change the curriculum so that the graduates from the department will be prepared to face the changing job environment. Under the leadership of the department head, Dr. Richard Koubek, sub-committees were formed to recommend the required changes in the areas of manufacturing, human factors, probability, statistics and statistical quality control and capstone design. The coordination of the activities of these four sub-committees was entrusted to a curriculum committee, consisting of representatives from each sub-group. This helped to achieve agreement among the faculty regarding the changes made in each of these areas first and then the final curriculum, thereby making the process relatively smoother.

Student Feedback on the New Curriculum

The new curriculum was introduced in Fall, 2005. Our department head, Dr. Richard Koubek met with the juniors in Spring, 2006 to get their feed back about the new

curriculum. All the students like the ability to pick a focus, or track, which is a main feature in the new curriculum.

Conclusion:

The new curriculum is well liked by the current students in the department, based on the feed back received from them. Out of the 125 students in the old curriculum, over 50 students have switched to the new curriculum. This new curriculum is an evidence of the continuous quality improvement efforts undertaken by the Department of Industrial Engineering at Penn State University.