Session 3257

An Integrated Education for ABET 2000: Experiences from a Small University

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Abstract

A fundamental premise gaining recognition is that an engineer without a good understanding of their role in society will not be a self-supporting contributor in the next millennia.

ABET 2000 allows and encourages variation in engineering education objectives, but requires justification and demonstration of achievement against those objectives. At St. Ambrose University we have built a modern, general, industrial engineering program by embracing the benefits that a liberal arts background provides and by emphasizing the fact that an individual has responsibility as a member of society first, and then as an engineer. By carefully integrating course experiences we have amplified the benefits to the students without increasing the total course hours requirement. We follow the philosophy of striving to produce a better student each time we teach a course. Further, our professors do this in continuous concert with each other and the overall mission of the university. We feel this approach puts us in an ideal position to satisfy ABET 2000 and provide our graduates with a solid understanding of engineering and an example of behavior that they can follow in their life's work.

ABET 2000

The Accreditation Board for Engineering and Technology (ABET) has introduced fundamental changes to the engineering accreditation criteria. The criteria provide ample opportunity for each institution to define the purpose and mission of the program, explain and justify its approach, and measure and demonstrate achievement. The new criteria are performance based, rather than prescriptive. This approach is analogous to the industry ISO9000 quality perspective. Program evaluation has shifted its focus to how the institution is achieving its desired outcomes. ABET 2000 encourages schools to improve continuously, in innovative ways, the engineering curriculum and pedagogy. By encouraging educational innovation, these challenging criteria provide a stimulus for making educational improvements. Under ABET 2000, each accredited engineering program must establish specific educational objectives, determine appropriate outcomes and their measures, and implement a system for ongoing evaluation and feedback to assure that the educational process is continuously improved.

An Overview of Ambrose Institute of Industrial Engineering

The Ambrose Institute of Industrial Engineering is a unique environment in which to earn an engineering degree. Situated in the college of business at St. Ambrose University, the institute benefits from a strong foundation in liberal arts plus a diverse student population. It is the integration of the traditional engineering education with a broad background in philosophy, theology and the arts that give the student real benefit in their field after graduation.

As a small, private, teaching institution, undergraduates are the focus of the faculty. Research is emphasized as a means to enrich student development rather than as a source of revenue for the university. Students and faculty can literally work side by side developing ideas and reinforcing engineering skills. The breadth and depth of the general education requirements enable students to develop crucial communications skills, beyond most traditional engineering programs.

Students at the Institute are immersed in an environment that focuses on people and the role they play in humanity. The world is not a series of discrete processes that function autonomously, but rather an intricate web of personalities, philosophies, problems and needs. To be a successful engineer, relating to the elements of this web is critical. A background firmly rooted in liberal arts is a strong foundation for understanding how and why people behave the way they do, and is a huge benefit to becoming a successful engineer.

A total of 132 hours is required to earn an industrial engineering degree. Of these, 54 hours are within the IE major. Math, physics, and chemistry account for another 24 hours, and engineering fundamentals provide another 17 hours. The liberal arts component is 37 hours. It is noteworthy that the operations research and engineering fundamental courses are taught by professors from the math and physics departments and adjuncts and not by the industrial engineering department.

Curriculum Principles

The Institute's philosophy is that the whole must be greater than the sum of parts to be most effective. For example, the fundamental skills of model building, creativity, problem solving, and communication are spun into the threads of graphics, design and writing. These threads are then used in many courses to weave the fabric we call engineering. Integration has been employed in two ways to implement this philosophy. First, in our beginning course we survey the microcomputer as a general tool, look at applications software for solving industrial engineering problems, and begin the use of the writing thread. Secondly, the threads are used directly to link various courses and reinforce important ideas. These are discussed and illustrated below using examples from the curriculum.

Integrating course contents and experiences to achieve overall objectives is emphasized. It is recognized that traditional engineering is rooted in mathematics and science. As curricula evolve, the application of the basic skills is specialized to form focused courses on particular topics (e.g., human factors, quality control, and simulation). It is common for these to be treated as discrete classes that, once completed by the student, are not seen again until after graduation (depending on what type of job the student takes). This compartmentalization, or specialization, allows for a 'boxtop' collecting mentality to develop in the students. After the successful completion (collection) of the required classes, a degree is awarded.

The Institute strives to break down many of the walls between courses. As a faculty we have built in overlapping topics in the curriculum to reinforce core competencies. Projects are given that take several semesters to be completed and require specialties across course topics. As the project moves from semester to semester, across course boundaries, different students are involved. A project may begin in a systems class, then move into a simulation class and finally into a design class; students may be involved in one or all of the courses. Understanding of "systems" does not end at the semester break, rather it is revisited later in the project for some other course. Knowledge and understanding must be maintained by the student throughout. The student is required to apply concepts formerly learned in subsequent courses. Courses are developed to build and use prior knowledge. Students are more comfortable with upper level courses because they have had exposure and experience before taking the class. Furthermore, students (especially traditional students with limited experience) begin to see the importance of the course material, and how it will be used after graduation. All courses are important to them, because they can see the usefulness rather than having faculty teach subjects without a clear purpose.

The culmination of the students' education is in the senior project experience, IE490. Student teams are given a real world project to solve. This requires extensive interaction with a host company, determination of the problem, developing and analyzing alternatives, and recommending a feasible solution. The role of faculty is that of a coach rather than an instructor. The student team posses the knowledge, and is given an unstructured problem on which they test their understanding of engineering and human behavior.

All students require an internship. This is not a formalized co-op program, but completion of at least one semester of work experience. For non-traditional students who work in industry, the criterion is easily met. Also, students who do work co-op or summer internship programs will also meet the criterion. Students are encouraged to seek an industrial engineering related job early in their education so that they can begin building their professional character.

An Advisory Board, composed of local industry management and retired experts, is assembled yearly to review the Institute's perspectives and provide their own. Industry needs, changes in the industrial engineering profession, and employment opportunities are discussed. The open forum has always been an enlightening experience for all.

Examples of Principles

Liberal Arts Components

The strong liberal arts component supports St. Ambrose's mission, which states "The mission of St. Ambrose University is to enable all its students to develop intellectually, spiritually, ethically, socially, artistically, and physically in order to enrich their own lives and the lives of others." The IE degree requires thirty-seven hours of liberal arts courses, and of this twenty-one are electives. Industrial engineering students must follow the liberal arts guidelines for the university, with only one exception that only nine instead of twelve hours are required in philosophy and theology. The remainder is in literature, history, arts, communications and social sciences.

Integration

An integrated experience begins early in the student's education. The freshman level course, IE290 - Problem Solving with Microcomputers, is an excellent example. The course title reflects the general theme of the course content which focuses on exploring a variety of industrial engineering topics by using application software and personal computers. Students study the topics and explore problem solving using the computer technology. However, this theme has two agenda, computer software and hardware introduction and an introduction to industrial engineering topics, which other institution's sometimes offers as two courses. There is debate within our profession about whether an "intro to industrial engineering" course serve useful purpose. We think they do, but we combine it with other topics.

Writing Experience

Industrial engineering students at St. Ambrose University cannot avoid learning to write reasonably well. All industrial engineering students are required to take two courses within the IE program designated "writing intensive." A "writing intensive" course, by definition, must contain a significant writing component, and it must include iterative writing exercises. As mentioned earlier, freshmen who take IE290 get early exposure to writing principles. Later, usually in the junior year, students take a second writing intensive course, IE351 - IE Design Lab.

A writing guide "Manual for Report Writing in Engineering Design" by Michigan Technological University is used to introduce students to technical writing in IE290, and then used again throughout our program whenever a course requires report writing. In this manner, a consistent writing style can be reinforced over the student's education. A second writing course (taught by English department) which is optional for most students, is a required course for all industrial engineering students. To help students relieve their writing stress or writing phobia, the university offers an academic support group that specializes in peer reading, review, and improvement for those students who need the additional help.

Writing experience within the IE curriculum does not end with IE290 and IE351, other courses contain significant writing components. For example, IE375, Computer-Aided Manufacturing contains six laboratory exercises that require well-written reports. IE350, Operations Management, has several projects that require report writing. These are several specific examples, however, most IE courses contain significant writing exercises.

Probably the most demanding writing experience is IE490, Senior Design Project, which requires a written plan, several memos and an extremely well written final report presented to the host company. The writing requirement in this course results in the reinforcement of the value of using writing as a tool for thinking, another valuable lesson.

Engineering Graphics

The role of engineering graphics within an industrial engineering curriculum bothers many universities. Some engineers may remember a time when engineering programs required two semesters of engineering graphics. A large share of this time was spent "on the board." Modern computer-aided design (CAD) software and hardware, along with pressure to reduce program hours, has diminished or eliminated engineering graphics in many programs. Questions remain. How much engineering graphics should be taught? What role should CAD play? Which product should be taught? Is CAD a more appropriate technical school subject? Should industrial engineers learn CAD on the job?

At St. Ambrose, industrial engineering students are required to take a one-semester course, IE110 Engineering Language/Graphics. Instead of focusing on the skills of engineering graphics, our focus is on the engineering design communication language. However, to be effective communicators, students must gain an understanding of the many concepts associated with engineering graphics.

Through the years, our program has struggled transitioning to a CAD environment. We still believe that students benefit by learning how to draw by hand, so we continue to use drafting board and sketching techniques. It is also realized that CAD is the tool used by many modern companies, therefore, there is definitely a need to expose students to this technology.

Our solution was first to consider how CAD might be used throughout the program. IE110 was clearly one course, but a different perspective of CAD concepts was taught in IE375 - Computer-Aided Manufacturing. It was first decided to introduce CAD in IE110, then reinforce it with a different perspective in IE375. Looking deeper into our program, we realized that students learn about visual communication languages in IE304 - Introduction to Design, and in IE415 - Systems Engineering. Lastly, IE490, Senior Design Project, requires students to express ideas visually.

Taking this perspective of a design language across the curriculum, the pieces fell together. In 1997, we decided to purchase a solid-modeling product that has sufficient capability to be used throughout our program. Our idea is to introduce students to it in IE110, then to reinforce it throughout their education. By the senior year and in IE490, when a drawing is required, students should be able to produce one. Providing pieces of CAD throughout the program has several benefits: all topics do not need to be crammed into one semester, various CAD capabilities can be provided in the appropriate topic, students get "four years" exposure to CAD, and having to revisit a software product makes it easier to use when needed.

Students in the IE110 course have enjoyed their CAD experience. There have been instances of several students' knowledge exceeding that of the professors. Some students have stated that they want more CAD experience, and others who had already taken IE110 before our new perspective have asked how they might catch up. So far this approach seems to be working well.

Design Experience

ABET suggests that a significant design experience be included in engineering programs. Some universities satisfy this requirement by developing a couple of courses that claim all hours as design hours. Our approach to satisfying this need has been different. We wanted to provide an integrated design experience; therefore, design experience has been included in at least a half-dozen IE courses. This also allows us to provide a more in depth experience as design projects will often cross classroom boundaries.

IE490, Senior Design Project, acts as the demand pull for the total design experience. Introducing design throughout the program assures that students are well prepared for IE490.

We begin the design experience with IE 110 Engineering Graphics. Here, a project to “design” some product is completed by each student. The student chooses the product, and one Patent has actually come about in connection with this requirement. The next step, after gaining some additional course experience, is IE 304 Design Fundamentals. This course studies design as a process, as a creative human activity, and as a philosophy of problem solving. IE 304 also requires a team project that includes the design of a product and the design of its production. The experience of designing items to fit and enhance human capability is included in IE 340 Ergonomics and Safety. The design activities usually associated with the computer aspects of the manufacturing engineering of a product are addressed in IE 375 Computer Integrated Manufacturing. The design approach to systems engineering is incorporated in IE 415 Systems Integration, wherelarge open-ended problems are addressed by the student teams in the required project (e.g., the operation of a foundry, the criminal justice system).

Continuous Improvements

The four industrial engineering professors at St. Ambrose take pride in their ability to understand the direction for the program, communicate and adapt to course content adjustments. One of the best examples of this cooperation is with the need to improve IE375 - Computer-Aided Manufacturing. Within this course, computer-aided design software was being used to illustrate CAD and its importance in a computer-aided manufacturing environment. The software was not state-of-the-art, and a decision was needed about what to do. Department funds were limited.

As discussed earlier, there appeared to be opportunity to teach CAD concepts in both IE110 and IE375. The course instructors collaborated on the idea, and together, submitted a small technology grant for internal funding for this experiment. The internal grant was awarded, which supplied several copies of solids-modeling CAD software and training.

In the immediately following semester, the new CAD product was introduced in both courses. Student acceptance was high, and it appears that our plan is succeeding. Our next challenge is to determine how best to use the new CAD within other courses.

This example demonstrates that our professors are always seeking ways to improve the program. We easily could have lasted several more years without any change. Instead of resisting change, we seek change and improvements. In our small setting, communication and implementation is easy. Bureaucracy, at least at this level, does not exist. Any new courses, change of credit hours, or removal of courses, however, do require acceptance from the university's Educational Policies committee. In contemporary terms, we have an "agile" program.

Program Operation

The perspective of the industrial engineering program is shared with students, faculty, employers and others. As leaders we make every effort to set a "do as we do" example. At the end of each semester students complete course evaluations. The university forms contain both fill-in-the-blank questions and essay feedback. The results are provided to us for our use in evaluating our teaching performance. The graduates are surveyed by the Career Development Center and we also get direct feedback on a personal basis.

The graduates are excited about being invited to return and share their experiences with current students regularly. The current students are extremely interested in what the recent graduates have to say. This interaction is powerful and insightful.

Feedback from our interns, graduates and their employer’s indicates that our students are significantly better prepared than engineering students from other schools doing similar assignments.

Summary

The hypothesis for the industrial engineering program at St. Ambrose University is that we are educating engineers for the future. These engineers must contain a strong set of analytical, communication, and integration skills. Our program, positioned in a small liberal arts university setting, provides that ability to deliver appropriate industrial engineering topics and to reinforce these throughout the program. We believe that we are very well positioned for ABET 2000 criteria. Formally documenting all this still needs to be done.

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Tom Hill is Professor of Industrial Engineering and has served as the Director of the Institute for the last three years. His teaching interests are in design, systems and problem solving. He earned the Ph.D. in Industrial Engineering from Arizona State University in 1969. He then served as an Industrial Engineering professor at Purdue University for several years. This was followed by more than 20 years experience in the aerospace industry serving in a wide variety of technical and management positions. This aerospace experience included the opportunity to serve in several pivotal roles which involved transforming a cotton field into an effective one million square foot high tech manufacturing, laboratory and office facility.

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Rick Jerz is an Assistant Professor of Industrial Engineering at St. Ambrose University in Davenport, Iowa, where he has interest in teaching manufacturing and computer related courses. He has an undergraduate degree from Illinois Institute of Technology, an MBA from St. Ambrose University, and a Ph.D. from The University of Iowa. In 1995 he was awarded a predoctoral fellowship from the United States Department of Energy (DOE) in "Integrated Manufacturing." He has more than 15 years manufacturing engineering experience, primarily with John Deere.

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George Kanzaki is Professor of Industrial Engineering at St. Ambrose University in Davenport, Iowa. He is a Certified Manufacturing Engineer (CMfgE,) and a Professional Engineer (P.E.). His teaching interests are in the traditional and modern Industrial Engineering methods and techniques. He earned a Mechanical Engineering (ME) degree from Stevens Institute of Technology, a Master of Science in Industrial Engineering (MSE) degree from Arizona State University, a Master of Arts (MA) degree and a Ph.D. degree from the University of Iowa. He served for over 23 years in the US Air Force and was a Management Engineering Superintendent. He was an Industrial Engineering instructor for the Army Management Engineering Training Agency on Rock Island Arsenal, Illinois for 18 years and has been with St. Ambrose since 1986.

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Michael Opar is Assistant Professor of Industrial Engineering at St. Ambrose University. His teaching interests are in the areas of human factors, quality control and simulation. He received his Bachelors degree in Industrial Engineering from Purdue University after which he consulted in facilities planning. He received his MSIE from Bradley University and is currently finishing his Ph.D. in Industrial Engineering from the University of Iowa. Beyond consulting, he has several years experience in a large process industry.