ENVIRONMENTAL EDUCATION FOR ALL ENGINEERS

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Project Description

The educational initiative described in this paper is based on three premises. The first is that the impact of manufacturing and manufacturing decisions on the environment can be profound; profoundly positive or negative. The fate of efforts toward systematic elimination of pollution in the environment rests to a great extent upon decisions made in manufacturing. There is no longer any question about the need for protection of the environment. Various groups may differ about the details and priorities but our society at large has reached consensus on the general concept of environmental preservation and protection

The second premise is that the only effective means to change the way these decisions are made is to provide a profit motive for the manufacturers, through new technological solutions. The United States Environmental Protection Agency (EPA) has now formally recognized that need through their "Common Sense Initiative." Under this plan, industries are encouraged to find technological solutions to problems of environmental protection which are consistent with good business practices.

The third premise states that to effect this improvement we must change the way engineers make decisions, which requires changing the way in which we educate them. Engineers are the individuals ultimately responsible for making the product, process and materials selection decisions for manufacturing. If we intend to change the decisions they make, we must change the way they arrive at these decisions. In my view, the case is no different than that faced a few years ago by American manufacturers, in the field of quality. Serious market threats by high quality offshore producers made US. manufacturers rethink their quality policies and they quickly found truth in the phrase "quality is free." They found that the most efficient way to manufacture is in the manner which produces the highest quality level.

EPA, through its Common Sense Initiative, has opened the door to this new era. The application of technology can make environmental protection consistent with lowering manufacturing cost just as the application of technology made improving quality more cost effective. It took a long time for American manufacturers to realize that improved quality could mean higher profits. We need to take advantage of that learning in advancing the cause of environmental protection. We need to help manufacturers by demonstrating that there is cost to be saved by eliminating waste and preventing pollution. Under the Common Sense Initiative, engineers will be called upon to develop new approaches in product design, materials selection and manufacturing processes to reduce manufacturing's impact on the environment. Under the previous pollutant-by-pollutant policy, industries tended to continue their previous practices and simply add controls, rather than adopt new technologies. Environmental engineers were called upon to find control and remediation solutions within the context of the existing set of manufacturing technologies. Now, there will be the opportunity to bring new technologies to bear on the problem. This will require a change in the decision models used by industries and will require new actions by engineers of all specializations, not j ust environmental engineers.

Academia has two responsibilities in this area. The first is to educate engineers in all specialties to account for environmental effects as part of their normal engineering practice. The second is to engage in meaningful research, development and technology transfer in the area of environmentally responsible materials, product and manufacturing design.

The Engineering Department at the University of Texas-Pan American undertook this "Environmental Education Initiative" because we realized that in order to change the way engineers are educated, we must start with the engineering faculty. Most faculty members were educated and trained during a period when environmental concerns were not important. These faculty members, even though they may have good intentions, do not have the necessary background or resources to bring these concerns into the classroom. Our educational project centers around providing that resource to the faculty,

Project Strategy

We have assembled six teams of educators, industry experts and government representatives from the United States, Canada and Mexico to identify and organize resource materials in the form of issues papers, case studies, laboratory experiments, field methods and design projects in the area of pollution prevention in manufacturing. In addition, we are developing an annotated bibliography of current literature in the field. The materials cover five technology areas;

plastics and composites,
chemical processing, materials and printing,
electronic manufacturing and assembly,
plating, painting and finishing, and
machining, welding and heat treating.

The five selected technologies very closely match the six industries EPA is piloting with their Common *Sense* Initiative:

Automobiles
Iron and Steel
Electronics and Computers
Metal Plating and Finishing
Printing
Oil Refining

In addition, we have a team working on International Legal and Regulatory Issues.

The product of this effort will be a reference book intended for use by engineering faculty of all disciplines, in a wide variety of courses across the engineering curriculum. The project, supported by a grant from Texas Natural Resources Conservation Commission, has three broad goals.

Goals of the Project

1. To produce camera-ready copy of the manuscript by the end of August, 1996.
2. To develop a strategy for dissemination of the materials through channels such as ASEE and the various engineering societies, to gain rapid adoption and use of the materials.
3. To encourage ongoing development and dissemination through a series of annual workshops and seminars on topics related to environmental protection and environmental] y responsible manufacturing.

The goals of the reference book itself are :
1. To integrate pollution prevention and waste reduction into the engineering curriculum.
2. To prepare students with the skills, knowledge and attitudes essential to making environmentally responsible engineering decisions.
3. To develop the materials in a tri-national effort and assure the materials have applicability in all three countries.
4. To initiate a process of continuously innovating and updating the materials through research and engineering practice and to foster dissemination through regular workshops and conferences.
5. To assist the engineering professor in making the study of environmentally responsible engineering a creative and enjoyable learning experience.

The teams have concluded that the preferred strategy for the book will be centered on developing a series of appropriate cases which can be used in a variety of engineering courses. One of the important tasks will be to make certain the book is "user friendly" to the engineering professor. It must be very easy to read, interesting and informative. It must make it easy for the professor to bring the information into all appropriate courses and it must assist him or her in preparing classroom and laboratory materials.

The use of case studies is beginning *to* emerge in engineering pedagogy. Case studies can place fundamentals of engineering science and engineering analysis in the context of engineering practice in a way that is interesting and useful for students. Design problems are particularly suitable for a case study approach since the solutions are not singularities and must be viewed in the context of the individual problem. (Dym, 1994)

It also presents the opportunity to introduce problem-solving skills into the curriculum earlier in the sequence of engineering courses and to demonstrate the application of problem-solving processes in engineering practice. To this end, we have included an" introduction to Students" which describes how to solve case study problems and a complete chapter on "The Engineering Design and Problem Solving Process. " These two additional resources can be used in a wide variety of pedagogical settings. As discussed by Ko and Hayes, problem solving is generally introduced implicitly rather than explicitly, causing many students to grope for structure in the problem solving process. (Ko, 1994) This resource will help students in transitional phases in their cognitive processes, developing formal operational methods of analytical thought. (Wankat, 1993)

These case studies also facilitate the introduction of the multiple and often conflicting objectives faced by engineers in practice. Real engineering problems solved in the context of their environmental, societal, economic and ethical constraints as well as their technical context, provide a much improved insight into the practice of engineering. The guidelines for ABET accreditation consistently require this broadened approach to engineering education and the structure of this new resource will respond to the recommendations of the ASEE Project Boards recommendations under "Engineering Education for a Changing World' in making engineering education relevant, attractive and connected. (A SEE Prism, 1994)

Case Study Example

Following is a case study, similar to the ones being developed by the various teams for inclusion in the book. It is provided hereto demonstrate how the case can be used on a variety of courses in the engineering curriculum and at different levels of courses, ranging from freshman introductory courses to senior design capstone courses. This example, taken from Texas Water Commission's Report, LP 92-05 is summarized here in shortened form, only to illustrate the nature of the cases. Additional information will be provided in the reference book, allowing broad use of the material.

Anheuser-Busch, Inc.

Anheuser-Busch, Inc. operates large breweries in Houston, Texas and many other cities. The process of making various malt beverages generates a waste stream of organics and organic solids suspended and dissolved in water. The customary practice had been to centrifuge the waste water to remove most of the solids and then discharge the remainder into the municipal sewer. Ibis effluent, still high in organic material, created a high BOD (biochemical oxygen demand), representing some 40% of the plant's BOD discharge for the Houston plant.

Concerns over the effect this level of BOD was having on the sewage treatment plant and its discharge as well as the cost for discharge permits lead Anheuser-Busch to investigate alternat ive strategies. The selected technological solution was the installation of an eight (8) stage residuals evaporator. This system, installed and operational within a six-month period, now evaporates the waste water, leaving a concentrated thick syrup with approximately 50% total solids. The evaporated water can be condensed and reused. The syrup is sold to an animal feed producer who mixes it with other molasses and whey streams to produce a high quality animal feed. Installation of the system has saved approximately $1.5 mil annually and has a payback period of five years. Some revenue is realized from the sale of the feed syrup.

Although not included here, a case like this one in the reference book will include considerable detail on the system used, its design, installation and operating costs and its energy uses. This will allow use of such a case in courses like heat transfer, thermodynamics, engineering economics, engineering design and others. One feature planned for the book is a cross reference table to help the faculty member select cases on a course-by-course basis. This table will cross reference each case for the various engineering aspects.

Structure for the cases in the book is:

1. Title
2. Key Words
3. Applicable Engineering Courses
4. Problem Statement

   Includes technical, economic, social, regulatory and environmental concerns and issues, written to require the student to decompose and organize the information provided before beginning the analysis. Other interesting but unrelated information should be included to challenge the critical thinking skills of the student.
5. Supplementary Information

   Includes information such as problem consequences, detailed design information (determined by intended courses and levels) and background information on the firm.
6. The Company's Solution

   A description of the solution implemented by the firm, recognizing that this is an answer, not necessarily the only or best answer. Includes the technical solution, environmental benefits and applicable economics.

7. Critique and Comments on the Company's Solution

    An objective discussion, helped to a great degree by investigations with the firm during the case research.

8. Suggested Classroom Discussion, Homework, Research Paper and Test Questions

    This portion will be scaled to several levels and course types.

We are designing the text with the suggestion that the instructor copy and distribute Items 4 and 5, and use the remaining information to supplement the case study itself. The cases, combined with the Issues Lists being developed for each technology area, will provide ample material to suggest research and design projects, field assessment methods and laboratory projects.

Summary

The project of developing this book has a number of interesting features. The notion of writing a reference book like this using a number of experts is certainly not new. However, the international and interdisciplinary nature of the teams as well as the number of institutions represented, makes it a valuable and enjoyable experience as well as a management challenge. I owe a deep debt of gratitude to all of the team members, team leaders and their respective universities, agencies and firms for their eager participation and support of this important project.

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Biographical Information

WAYNE E. WELLS came to academe after a thirty year career in industry and international consulting in engienering. He holds a BS from The University of Cincinnati in Metallurgical Engineering, Master of Science in Business Administration from Eastern Michigan University, Master of Science in Industrial Engineering and PhD in Industrial and Manufacturing Engineering from Wayne State University. Dr. Wells is currently on the faculty of the Engineering Department at The University of Texas-Pan American where he teaches courses in Manufacturing Engineering.