MATERIALS ENGINEERING, EXECUTIVE STYLE: THE CHALLENGES OF MODULAR EDUCATION

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Abstract*-This paper describes and gives an example of the modular approach to curriculum development and implementation for post-graduates who are practicing engineers and scientists in an executive-style engineering management program. The goal of this MS degree program is to enable future engineering managers to make better business decisions. The objective of the Materials module is to understand the complexity of the societal issues that impact upon materials selection. The module challenges the engineering leader to understand the history and practice of materials utilization, and to be prepared to participate in the creation of strategies and tactics for materials resources. Using a global perspective, the class studies how today the broad societal issues of health, safety, energy, conservation and the preservation of the environment are taking an equal position to the traditional motivators, namely, economics, technical and geopolitical influences. The paper details aspects of the difficulty in developing and maintaining a balanced curriculum, one that would be meaningful for a class cohort composed of practicing engineers with diverse undergraduate preparations and lifetime experiences.*

Index Terms-Curriculum development, engineering leadership, modular education.

INTRODUCTION

In an earlier paper [1] on "Engineering Leadership Through Tradition and Innovation", the concept that "Engineering is a Social Enterprise", was discussed, and those who would be the leaders in our society should emerge from the ranks of those who best practice the best engineering. In that paper, we described the program of engineering leadership at The Gordon Institute, where understanding the concepts of engineering leadership and the rigors of project management are the basis of the continuing educational program.

In a subsequent paper [2] on "Balancing Fundamentals and Practice in Engineering Management Education", we presented some of our successful experiences with the modular method for curriculum development. We described how the module enabled the selection of the most appropriate learning facilitator for the subject matter, e.g. consultant-practitioner or traditional research-driven faculty member.

We also discussed the Project that has been the cornerstone of the educational process at The Gordon Institute. The project stresses practical work in a real-world environment. In this effort, the organizational sponsor of the project gains a valuable product and maintains a close relationship with the student throughout the product design and implementation period. More than one hundred projects have been conducted over the past ten years that have drawn upon the expertise of the Institute staff and support facilities. These have been in the areas of electronics systems and components, including some with embedded software; software and MIS development; mechanical components and systems; and, medical product systems.

In the third paper in the series [3]"Industrial Problem Solving in Post-Graduate Engineering Education" , we introduced the concept of the Practicum which serves as a supplement to the Project for the MS degree. The Practicum offers the opportunity for students, staff and faculty to learn together while solving a critical industrial problem. That paper described case histories and experiences where teams of post-graduate engineering students worked on-site at companies as a consultation team. For example, at one company site, the team provided process improvement recommendations on the electronic component recovery process. They helped design a system to identify electronic modules with reusable or hazardous components, and investigated methods for automated component extraction

The next paper in the series [4] described a modular course of study that prepares graduate students and the practicing professional in continuing educational modes to understand environmental management systems. The goal of the course was to help the student to make better business, policy, and organizational decisions as environmental management systems become implemented throughout business and governmental organizations. That paper described the six-year history of academic projects that have linked business needs with educational opportunities. That paper presented the scope and accomplishments of five post-graduate students in the process of earning their Masters degrees with a multi-disciplinary and interdisciplinary approach.
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OBJECTIVE

This paper will describe and give an example of the modular approach to curriculum development and implementation for post-graduates who are practicing engineers and scientists in an executive-style engineering management program. The objective of the Materials module is to understand the complexity of the societal issues that impact upon materials selection. The module challenges the engineering leader to understand the history and practice of materials utilization, and to be prepared to participate in the creation of strategies and tactics for materials resources. Using a global perspective, the class studies how today the broad societal issues of health, safety, energy, conservation and the preservation of the environment are taking an equal position to the traditional motivators, namely, economics, technical and geopolitical influences. The paper will give details of the difficulty in developing and maintaining a balanced curriculum, one that would be meaningful for a class cohort composed of practicing engineers with diverse undergraduate preparations and lifetime experiences.

CONSTRAINTS

Every continuing education program has its own opportunities and constraints, and this program is no exception. For example, this program appeals to a regional audience of engineers from many different industries, such as electronics, telecommunications, biotech, pharmaceutical, software, and medical devices. Some of the students are "expert" while others, like the software creators are "neophytes." Therefore the structure of the module must provide a variety of student performance methods. Further, the module needs to be consistent and supportive of the themes of product development and project management, which are the core competencies of the curriculum.

The course and module format must be shaped and linked to other courses and modules within the curriculum. For example, in the course on Quantitative Methods, the modules provide the student with a broad perspective of engineering tools and techniques, such as the use of artificial intelligence software for modeling and simulations. A frequent linkage each year from the Modeling to the Materials Module is the development of models to predict metal pricing using many databases and elements of economic geography. Further, on linkages to other modules, the module content needs to support the understanding of product innovation, the concept of the life cycle phases of such developments is stressed

By far, the greatest constraint is the amount of time that all of the students are in the classroom, limited by the alternate week-ends only format. Therefore, a way had to be found to balance the classroom time with focused mentor time.

CLASSROOM

Topics covered in the classroom provide a broad overview through the use of case histories, namely, "Car Wars" or the battle for materials in automotive products; another is "Can Wars" or the battle for materials in the beverage containers provide ways for the students to monitor and assess decisions of materials selection.

The aluminum industry is examined as a measure of broad economic conditions, capital intensity as a barrier to entry, energy management, and environmental issues, e.g. recycling.nother topic is entitled, "Get the Lead Out of the Electronics Industry: A Continuing Case History."

After a brief background, the current categories of Lead usage, or the common applications of Lead are discussed. We start with Paints, then Gasoline, then, Plumbing, to Lead-acid Batteries, and finally to PWB Solder Joints. In each application, we examine the historical reactions taken by industry and society. Further, we discuss the readiness for new solutions, their impact and resolutions.

The modular construction of the course enables topics in emerging areas to be added with ease, such as biomaterials, nanotechnology, and superconductivity, and facilitates the introduction of industry experts on these topics.

TERM PAPER CREATION PROCESS

The module format provides several ways for student learning to be measured. The most critical measure for the students is to complete an end-of-term report that shows an understanding of the principles learned in the course and applied to the materials selected for the report. In each report, the technical, economic, geopolitical, health & safety, energy management, and environmental factors need to be addressed. Each term paper achieves value for the student and demonstrates the desired learning by following a paper preparation process that has many milestones and check points.

Initially, the concept and the expectations for learning within the paper are described in a traditional manner at the beginning of the semester. Examples of the titles and the scope of papers from prior years are shown in Table I: Traditional Topics and Table II: Sponsor Focussed Topics. The specific format is also discussed with particular emphasis upon several aspects of desired performance within each paper. For example, the students have historically had a difficult time in writing the Abstract, and, being able to differentiate the Abstract from portions of the Introduction Section, and again, from the Conclusion and Summary Sections.

A few weeks after this initial in-class discussion, the students are required to send / email an informal note that contains the Title of the paper, and some descriptive

words, "bullets", or such to help frame the topic. My rapid response (by email usually) will serve to clarify and define the sense of the total paper. Together with the student, we will explore whether the paper will be a personal learning experience related to a current or future workplace project; or, will it be a part of the person's desire to explore an advanced technology; or, does the topic provide the student with an opportunity to examine an avocational topic outside of the workplace?

Shortly thereafter, a first draft of the Abstract is submitted along with the beginnings of the Bibliography, the later following several suggestions in both scope and the diversity of sources, especially in this age of website mining! In the final draft of the paper, a Reference Section will have been created from the Bibliography to demonstrate the proper use of citations. Again, rapid response comments and feedback are provided to assure the student that she is on the "desired path", and that the scope of the paper is appropriate and the length is manageable. Many students begin this effort with high ambition and excessively broad scope, and, it has been common practice to help them focus on fewer directions.

About this time in the semester, a small number of students have become "disenchanted" with their topic, and start afresh. Most however, provide a rich Bibliography, and, become engaged in dialogues with me on detailed aspects of their work. Eventually, the "due date" arrives, and the term paper is submitted. Most papers meet expectations over the range of acceptable grades; some do not, and become REWRITES. Several papers, and happily an increasing number, are beyond expectations, as the student exhibits high zeal for a topic. This has occurred when the topic for this paper becomes a "trigger event" for the personal MS Project for the MS Engineering Management degree. One particular example was a paper on materials selection in selected energy generating systems, viz. fuel cells and stationary gas turbines. Subsequently, the student completed his MS Project on the design and implementation of a selective catalytic reduction system.

When topics for papers are selected for personal life interest, the focus is usually on materials in sports and recreation. One student examined the "reality or hype" of the manufacturers' claims of advanced materials for golf balls and golf clubs; another examined fishing rods. One unique life interest paper was on the evolution of the sewing machine. This paper by Yoko , a female engineer from Japan, derived from casual conversations on "how different her new, highly automated machine was from that of her mother back in Japan." The discussion of the paper topic evolved from a "form follows function" line of thinking to changes in women's life styles, and, ultimately to the role of women in Japanese society today, namely, the workplace and in the home. This paper gave Yoko a chance to explore a wide range of topics including patents and Massachusetts' history of technology in the body of the Singer Sewing machine.

Two students opted to explore the activity to remove lead from the electronics industry on a global basis. One student chose to accept "as commercial fact" that the marketplace forces will cause lead to be banned. His next steps for his company were to prepare them to manufacture PC Boards with lead-free solders, providing the technical and commercial concerns surrounding implementation. The second student "tackled the myth" and tried to make sense of "the environmental need or the political agenda". Both were able to demonstrate their competence of critical thinking in the realm of materials and processes, energy and the environment.

TABLE I

TRADITIONAL TOPICS

Automotive Components and Systems
Batteries for portable Energy Sources
Materials in Sports and Recreation
Aerospace Components and Systems
Energy Sources for Automotive Applications
Environmental Aspects and recycling
BioMaterials and BioMedical Devices
Material Life Cycles

TABLE II

SPONSORED-FOCUSSED TOPICS

Electropolished Stainless Tubing in the High Purity Process Equipment Industry
Evaluation of the Printed Circuit Board Laminate and the Impact of the Laminate on the Circuit Performance
Complex Cleaning Solutions Used in the Aeropsace Industry
Materials and Manufacturing Processes for Low Observable Shipboard Antennas
From Bauxite to Axila: Aluminum in Antiperspirants

SUMMARY

This paper has described a modular course of study which prepares graduate students and the practicing professional in continuing educational modes to understand the complexity of the societal issues that impact upon materials selection. The module challenges the engineering leader to understand the history and practice of materials utilization, and to be

prepared to participate in the creation of strategies and tactics for materials resources. Through the use of a term paper, the individual has an opportunity to demonstrate how this understanding is applied to a real-world topic in support of a company or personal career-path goal.

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