An Innovative Course on Elements of Manufacturing Systems for Non-Engineering Students

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1. INTRODUCTION

The rapid changes in technology, the associated increase in skill requirements for technology-oriented jobs, and the shrinking population of people with the necessary skills are making it difficult for U.S. industries to compete in the international market. The knowledge of technology is essential for functioning effectively in today's technological society, contribute to its growth, reap its benefits, and minimize its hazards, regardless of one's career interests. A basic understanding of science and technology is crucial not only for applying the fruits of technology effectively, but also for making decisions on related issues that impact human existence in the present and in the future.

Traditionally, engineering schools have been the source of new graduates competent in the new technologies who can meet the needs of the industry and society. However, educators are often faced with more than the mere challenge of conveying technical information to their students. Students, on the other hand, find the information conveyed uninteresting, unmotivating, and fail to recognize its value and career potential. These are also some of the reasons for the considerable student retention problems experienced among first and second year college students, and the increasing need for innovative curricula to counter these problems [1].

In this NSF funded effort, educating first and second year students on manufacturing systems is proposed as a solution for countering some of the mentioned problems. With the support provided by NSF, an innovative course is being designed, developed, and offered to non-engineering students at Northern Illinois University. In this poster session, the details of this course, its innovative design, its assessment procedure, and the preliminary results obtained are discussed.

2. THE NEED FOR EDUCATING NON-ENGINEERS ON MANUFACTURING

Two obvious questions one may ask at this point are why educate non-engineering students on manufacturing and what special place manufacturing has in this regard. Manufacturing enjoys a unique position among the different applications technology. It touches the lives of people in modern society in almost every aspect: as producers, consumers, suppliers, and objects of its environmental and societal impact. Particularly, a significant section of the society provides a vital support to the manufacturing industry in the form of technical, informational, financial, legal, and artistic expertise, as well as services related to the development of human resources and the sale of products.

Manufacturing differs from the established engineering disciplines, such as mechanical and civil engineering, which are defined traditionally in terms of both educational degree and specialized expertise. Manufacturing is, in contrast, more defined by the functions performed and demands multidisciplinary

capabilities. It is also an integrative field, bringing together concepts from the physical and material sciences that deal with equipment and tools, with concepts from the biological and social sciences that deal with human factors, and tying them together with the use of mathematical modeling and principles of management applied to production. In view of this, students with diverse skills and interests can readily relate to this field.

Knowledge about the scope of manufacturing and how it encompasses various disciplines in science, humanities, and engineering is generally lacking among students. This further leads to their inability to comprehend the value of basic courses in math, physics, or chemistry. Therefore, manufacturing is an ideal vehicle for educating non-engineering students on the value of basic math and science topics and for helping these students understand and appreciate the role of manufacturing in today's society and its career potential for people with diverse skills, interests, and background.

3. RESEARCH OBJECTIVES

This course is intended primarily for non-engineering majors in the first or second year of their degree programs, and the objectives of the course have been defined from the students' perspective as follows:

1. Comprehension: Understand the basic manufacturing concepts and the scientific foundations upon which they are built.
2. Application: Learn the application potential of the manufacturing knowledge gained.
3. Creativity: Identify opportunities for improvement in a design, plan or function and synthesize acquired knowledge generating new ideas for improvement.
4. Motivation: Develop increased interest in the manufacturing area and its underlying sciences.
5. Integration: Identify the relationships between the components of manufacturing, both along the life cycle of a product and among the functions of a manufacturing system.
6. Diversity: Interact in the classroom with groups composed of various skills, background, and interests.

If the goal is to reach a majority of the students, motivate them to learn and understand, and convey the course material effectively, then the course or curriculum should be designed to address the objectives mentioned above.

4. DESIGN OF AN INNOVATIVE COURSE ON MANUFACTURING SYSTEMS

Educating first and second year students on manufacturing systems and requires a careful design of course content, level and depth of coverage, and teaching methods. Course contents must be broad enough to cover the scope of activities in manufacturing systems and to relate them to basic science and mathematics without diluting the depth of coverage. A balance must be maintained between theoretical topics and application in order to keep the students challenged, but not discouraged. Finally, appropriate teaching methods should be chosen for the specific topics covered and should match students' preferred learning styles.

The course design consists of three levels, namely, (1) Manufacturing Concepts, (2) Learning Styles, and (3) Teaching Styles, as shown in Figure 1. These three levels have been integrated together innovatively to educate non-engineering students on manufacturing concepts. The following sections discuss the details of the course design along these three levels.

4.1 Manufacturing Concepts

The major functions of a manufacturing enterprise are introduced to students at a higher level in this course, emphasizing the complete manufacturing life-cycle. The four major functions of the manufacturing enterprise as defined by Harrington, Jr. [3] are:

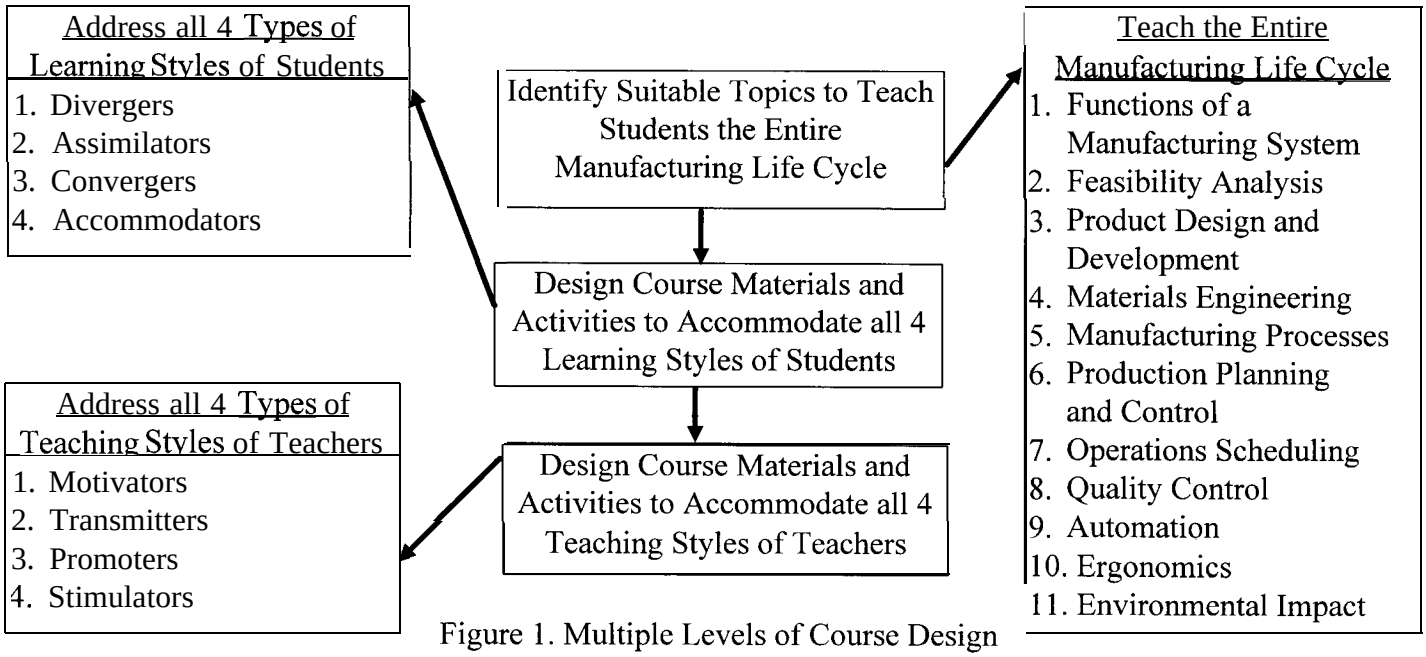

Figure 1. Multiple Levels of Course Design

1. *Manage the enterprise:* Administer activities, establish programs, establish policies, provide resources.
2. *Manufacture the products:* Manage manufacturing, develop products, produce products, ship products, support services of product.
3. *Market the products:* Assess needs of the marketplace, establish marketing policies, advertise products, sell products, service products from the field.
4. *Support Corporate Activities:* Provide data processing, provide legal counseling, manage personnel, manage funds.

A sample list of topics covered in this course is as follows:

1. Introduction to Manufacturing
2. Life Cycle of a Production System
3. Product Design and Development
4. Materials Engineering
5. Manufacturing Processes
6. Planning for Production
7. Quality Control
8. Operations Scheduling
9. Manufacturing Automation
10. Manufacturing and the Environment
11. Ergonomics in Manufacturing

It is hoped that this emphasis on the complete manufacturing life cycle will interest and motivate students to understand and appreciate the relevance of manufacturing in today's society, the possible career opportunities in manufacturing for people with different skills and background, and the scope for application of basic math and science concepts in learning and understanding these manufacturing topics.

4.2 Learning Styles

One of the advantages of integrating the preferred learning styles into an introductory course on manufacturing is that manufacturing concepts are ideal for such a course design compared to pure theory-oriented topics. Manufacturing concepts can be introduced to students through motivational issues (Why?), formal lectures on facts and information (What?), application examples and experiments (How?), and exercises in synthesis and evaluation (What if?). For each topic covered in this course, homework exercises have been designed to cover these 4 quadrants of the learning cycle as defined by Kolb [4]. Homework problems from the

"Why" quadrant motivate "divergers" to understand the reasons for learning a topic, problems from the "What" quadrant help "assimilators" understand the basic facts and concepts about the topic, the problems from the "How" quadrant allow "converges" to apply the basic facts and concepts to solve simple problems, and problems from the "What if' quadrant help "accommodators" reflect on other possible scenarios and synthesize what they learned.

Along with the homework exercises, the course topics have been augmented with appropriate laboratory experiments and design exercises to accommodate different learning styles. The laboratory experiments include: (1) Conceptual Design Exercise, (2) Material Conversion Experiment, (3) Quality Control Experiment, and (4) Human Factors Experiment. After completing each laboratory experiment, students are required to answer a number of questions related to the laboratory experiment which once again cover the four quadrants of the learning cycle. This is to ensure that the laboratory experiments also address the four quadrants of the learning cycle and accommodate students' different learning preferences.

4.3 **Teaching Styles**

Similar to students' learning styles, teachers also have preferred teaching styles which also can impact a course and the information conveyed to the student. Claxton and Ralston [2] have classified teaching styles under four different categories as: Type 1 (Motivator), Type 2 (Expert Transmitter), Type 3 (Promoter or Caoch), and Type 4 (Stimulator) teachers. Claxton and Ralston have concluded from their studies that Type 2, the professor-dominated teaching style, is the most prevalent one in engineering curriculum and that the faculty do not generally teach to accommodate different learning styles of students in their courses.

The four teaching styles have been accommodated in the course by the careful design of course activities, such as group discussions, videos, computer demonstrations, laboratory visits, guest speakers, and conceptual design projects. These activities are intended to supplement the traditional professor-dominated teaching style which does not match the learning style of all students.

5. **COURSE ASSESSMENT**

One of the essential components of any good course design is its assessment mechanism, This includes designing proper assessment procedures and analyzing and interpreting the results appropriately. For the course discussed in this poster session, four different assessment procedures have been established:

1. Survey of students on the first day of class on their background, objectives for taking the course, etc.
2. Survey on all the topics covered for each examination, conducted during the class before each examination, focusing on different learning styles, teaching styles, course objectives, etc.
3. Survey of students on the last day of class on the same issues surveyed on the first day of class.
4. Survey of expert consultants on the course material and course activities.

The surveys conducted on the first and last day of class are useful for assessing the impact of the course on students, their learning, "before and after" perceptions on manufacturing, the value of learning math and science topics, etc. The topics survey provide a detailed assessment on each topic from the perspective of learning, teaching, etc.

The results of the surveys have been analyzed and useful sampling statistics have been calculated to provide the necessary feedback for improving the course. The assessment mechanism also includes the evaluation of the course design, content, activities, and outcomes by expert consultants. Currently, the course is

being evaluated with the help of consultants from university departments such as Education, Physics, Curriculum and Instruction, and the Office of Cultural Diversity, and also by a consultant from the manufacturing industry. The insight and the input provided by these consultants have been valuable for improving the course.

6. CONCLUSIONS

In this poster session, the details of an innovative course on manufacturing systems that gives non-engineering students an opportunity to learn, appreciate, and understand the role manufacturing plays in today's society and the potential it has for career opportunities was discussed. The course has been innovatively designed to accommodate the different learning styles of students and teaching styles of instructors. This course is currently being offered as a general education course under the title, "IENG100 Elements of Manufacturing Systems" to non-engineering students at Northern Illinois University and it has attracted both male and female students from business, computer science, art, economics, and technology. A detailed assessment mechanism has been implemented to evaluate periodically the organization, content, teaching style, learning preferences, etc., of each topic covered in the course and also the course overall objectives. The results of the assessment studies indicate that the students' reaction to the course has been very positive and encouraging and that they benefit from the innovative course design and some have also indicated an interest to transfer to engineering.

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