

## "Creative Project Model"- A Research Experience for Undergraduate Students

Ajay P. Malshe  
Materials & Manufacturing  
Research Laboratory (MRL)  
Department of Mechanical Engineering  
University of Arkansas, Fayetteville, AR 72701

### Abstract

***Tell them-they will forget***  $\Rightarrow$  ***Show them-they will remember***  $\Rightarrow$  ***Involve them- they will understand***  
- Anonymous

Engineering is a bridge between fundamental research laboratories and manufacturing industries. Undergraduate students need research experience to be introduced to the interdisciplinary nature of product development and manufacturing. Research experience complements the undergraduate education that is concerned with the basic concepts of science and engineering.

The author, in the last three years, has involved five undergraduates through *testing new ideas* to develop material processing and manufacturing technologies. These idea-based projects are termed by the author as "creative projects". Each creative project is completed in two semesters. Due to the exposure to novel ideas, state-of-the-art technologies and major academic achievements encountered in these creative projects, three of the five undergraduate students have chosen to pursue higher education and are currently graduate (MS/ Ph.D.) students with the author. The fifth one has decided to be a graduate student after the completion of his BSME degree in 1998. In this paper, the author intends to unfold and describe a novel "creative project model" and share his views on establishing effective avenues for undergraduate research experience which could benefit students, influence their future choice of careers, and benefit manufacturing industries.

## **I. Introduction:**

At the University there is a total enrollment of approximately 15,000 students. It is the state's primary institute granting doctoral degrees. There are 17 faculty members in Mechanical Engineering teaching 325 undergraduate and 20 graduate students. Conventionally, the state has a poultry and farm-based economy. Currently, an experimental program to stimulate competitive research in the areas of science and engineering is funded through various agencies in the state. In the past five to seven years, particularly in the Northwest Arkansas and overall in the state, the Manufacturing - Machining sector has seen rapid growth and progress. Manufacturing ranks third in revenue generation in the state as an aggressive contributor to the state's economy.

In September 1995 the author established the Materials and Manufacturing Research Laboratory (MRL) in the Department of Mechanical Engineering. Research, development, testing, and education of advanced tooling for materials synthesis, processing and manufacturing are the objectives of MRL. Presently, the laboratory has two faculty, three Research Associates, six graduate students, and three undergraduate students working on various research projects. MRL supports these industries by producing a competitive engineering work force.

## **II. Background of Establishment of “Creative Project Model”:**

An engineering workforce skilled in addressing interdisciplinary product design, development, and manufacturing needs is one of the keys for success to the US manufacturing industry in the 21<sup>st</sup> century. *Active education*, where students are exposed to the new technologies by individual involvement, could become a primary medium for bringing new tools and technologies to general community usage. For example, the trend for the coming century in the automobile manufacturing and aerospace industries is Green flexible machining. This new trend is a paradigm shift from current infrastructure. Are our students educated to this rapidly changing trend? The education and training plan where students are actively involved and trained in progressing manufacturing field and nurtured to adapt to rapidly changing manufacturing environments could be a successful strategy to address the above and similar concerns.

Currently the following courses are being taught in the Mechanical Engineering Department by the MRL faculty, 1. Introduction to Materials (MEEG 2303) - a course for undergraduate students, 2. Materials Laboratory (MEEG 4303) - a dual level course, 3. Creative Project Design I & II (MEEG 4132&4133)- for senior undergraduate students, and 4. Advances in Materials (MEEG 5393)- for graduate students. MEEG 2303, MEEG 4303 and MEEG 5393 satisfy the students' need for classroom education in materials and hands-on experience in materials synthesis and analysis in the laboratory using the state-of-the-art equipment. Initially, the author has tailored Senior Design MEEG 4132&4133 courses to establish and demonstrate a working “Creative Project Model (CPM)”. Education through the CPM is geared to involve undergraduate engineering students in the “idea-based” research projects.

### **III. Creative Project Model:**

#### **III.1 Description:**

The CPM class is conducted in two semesters with the aim of educating students to be able to choose, manage and execute a real life R&D problem that is novel and is recommended by either industries or by the departmental faculty. Typically, the students either work independently or in a group on such interdisciplinary problems.

The projects are based upon new academic ideas and experiments are geared to demonstrate a proof-of-concept of such an idea. It demands creative thinking on the part of the advisor as well as the student(s) in each step of the project. This maintains a close working relationship between students, advisor, and industry throughout the course of the project. The author has developed a project management and execution scheme in two semesters in four steps. The student is first asked to follow a certain procedure with proper explanation.

**Semester – I: Literature search through CD-ROM and on-line library searches:** - Students get familiar with the state-of-the-art knowledge and learn library usage for practical applications.

**Semester-I&II: Designing of the experiments and/or final deliverables:** - Designing is one of the very important components of material synthesis, processing and successful product fabrication. In this step students learn to implement their designing skills in the product design. They also learn how to design, organize and manage experiments for the successful development of the final deliverable in a "time bound" project. In the current job market, companies look for student engineers with interdisciplinary background that can make them flexible for versatile and time bound projects with different customers. Experience in the project makes the students better designers, and successful creators and managers for such *flexible*-job / career needs.

**Semester I & II: Learning desired specific material(s), material synthesis and analysis techniques:** - In the project students will learn about relevant materials such as diamond coatings or Al<sub>2</sub>O<sub>3</sub>-ZrO<sub>2</sub> coatings, WC-Co composites. Also they will learn about analytical techniques such as x-ray diffraction (XRD), scanning electron microscopy (SEM), on contact surface profilometer for material analysis and state-of-the-art material processing techniques such as chemical vapor deposition (CVD), laser etching, or laser deposition.

**Semester II: Execution of the experiments, analysis of the data and report writing:** - At this stage students are encouraged to work more independently, based upon their previous performance. In specific interdisciplinary problems they are also encouraged to work with graduate students and post-doctoral fellows, other than faculty advisors, where they feel truly welcome in the research environment. With other students they get familiar with 1. working in a group (teamwork), 2. experimentation, and 3. analyzing the data and converting that into a sensible outcome. At the end, writing the "story" of their project puts their technical writing to the test. They may go through various research publications to learn better technical report writing skills.

Due to better planning and designing of experiments and better execution of the plan, undergraduates may get a publication out of such exploratory research on their creative ideas.

The education through creative projects is unique as it trains the student to integrate designing, material processing and manufacturing skills. For the instructor it offers a unique opportunity to encourage undergraduates for higher education. In the coming years the author would like to continue this operation involving more undergraduate students in such new exciting projects with other faculty in the department and with collaborating industries.

**III.2 Success and Advantages:**

The CPM is a prolific avenue to involve and motivate undergraduate students in the research and development environment. It has very long lasting benefits. Motivating outstanding undergraduate students for a graduate program through research experience in CPM is of great significance to the overall goal of generating skilled engineers for the changing manufacturing needs. The following table describes a summary of the author’s CPM undergraduate student cases and their success.

**Advantages of CPM:**

- It provides *practical* active education desired for the current job market
- It provides *complementary* education to classroom teaching
- It could provide students *additional benefit* in the form of publication / report / conference presentation
- CPM is a *workable* model
- CPM provides *true Practical Education* = Training + Academic Nourishment
- Generates *skilled engineers*

Name of the Project	Present status
Development of a Non-destructive thickness measurement technique	Working on MEEG** MS thesis
Laser cleaning of hard surfaces	Working on MS - MEEG**
Multiple laser processing of diamond surfaces	Working on PhD - ELEG**
SMART tool for the <i>insitu</i> observation of machining process	Working in a manufacturing company
Construction of a mechanical assembly for a novel 3-D flex electronic package	Working on BSME

\*\* Working with the author on various projects; MEEG –Mechanical Engineering; ELEG- Electrical Engineering.

**IV. Summary:**

In the last two years, the author has formalized and demonstrated CPM’s *initial* success with five examples. Due to the prolific research experience three students have joined a masters program and one has joined a leading manufacturing company; selected from a nationwide competition. The above text describes the background, strategy and the steps for its successful

implementation. Indeed, CPM provides research experience to the undergraduate students. Such experience produces skilled engineers for the dynamic manufacturing environment of the 21<sup>st</sup> century.

### **Acknowledgments:**

The author would like to thank the Chairmen of the Department of Mechanical Engineering and the Department of Electrical Engineering respectively, for the constant encouragement during the last two years of CPM development. Also, the author thanks various graduate students and post-doctoral fellows for providing encouragement and support to the undergraduate students who worked in the CPM.



Dr. Ajay P. Malshe is an assistant professor of mechanical engineering and an adjunct faculty of electrical engineering, University of Arkansas, Fayetteville, AR. He is a materials scientist and engineer and has over 60 publications and holds two patents. Areas of his interest include advanced tooling and high-density electronics packaging. He is also active in IMAPS, ASME and other related societies.