TEACHING AND LEARNING ASPECTS FOR AN ONLINE GRADUATE COURSE ON DESIGN FOR MANUFACTURABILITY

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ABSTRACT

An online Master of Engineering program is offered at the University of Wisconsin - Platteville. The curriculum consists of core courses, technical emphasis courses, and elective courses. Curriculum improvements are made through revisions to existing courses and the introduction of new courses. A course on Design for Manufacturability (DFM) has been developed by the author and the course went online for the first time in Fall of 2003. Key elements in the development, teaching, and learning aspects of the course are addressed. They include an overview of the Master of Engineering curriculum, background of DFM, the role of DFM in the curriculum, major topics in the course, and strategy for teaching / learning DFM online.

THE ON-LINE MASTER OF ENGINEERING PROGRAM

The Master of Engineering degree program offered at the University of Wisconsin - Platteville is 100 % online. The program requires 30 credits of advanced course work. The student must complete at least 15 credits at the 700 Level. The curriculum consists of Core Courses, Technical Emphasis Courses, and Elective Courses. Table 1 below lists specific courses and requirements.

CORE COURSES		
	Mathematics (Choice of 1 course)	
	MATH 5230	Linear Algebra
	MATH 6030	Statistical Methods with Applications
	Computer Applications	
	CEE 7830	Optimization with Engineering Applications
	Technical Communications (Choice of 1 course)	
	COMM 5010	Business Communications
	ENGL 5000	Technical Writing

	Engineering Management (Required)	
	PM 7010	Project Management Techniques I
TECHNICAL EMPHASIS COURSES (Total of 9 credits in a single emphasis area)		
	Engineering Design	
	CEE 7830	Optimization with Engineering Applications
	MIE 6800	Finite Element Analysis
	MIE 7300	Experimental Design
	MIE 7550	Product Design and Development
	MOE 7980	Independent Study in Engineering (1 - 3 Cr)
	Engineering Management	
	MIE 6030	Production and Operations Analysis
	MIE 6830	Cost and Value Analysis
	PM 7020	Project Management Techniques II
	MOE 7980	Independent Study in Engineering (1 - 3 Cr)
ELECTIVE COURSES (Total of 9 credits from this area or from any of the above courses not taken)		
	BSAD 5620	Financial Management
	BSAD 6110	Management Science
	BSAD 7540	Advanced Quality Management
	CEE 5810	Occ. Safety & Health for General Ind (2 Cr)
	CEE 5820	Safety & Health for Construction Ind (2 Cr)
	CEE 7160	Advanced Foundation Design
	MIE 7330	Appl. of Control Theory in Dynamic Systems
	MIE 7730	*Design for Manufacturability*
	MIE 7830	Systems Engineering Management

Table 1

The degree is tailored for those seeking a cross-disciplinary terminal degree. No campus visits are necessary. Students must maintain at least 3.00 GPA. At least 50 % of the credits must be earned from the University of Wisconsin - Platteville.

BACKGROUND OF DESIGN FOR MANUFACTURABILITY (DFM)

In the current global competitive environment, it is essential that manufacturing be performed at peak efficiency. To do so requires the understanding, planning, implementing, monitoring, and controlling of many functions that affect manufacturing. One important function that influences manufacturing greatly is design. As well known as the idea of design for manufacturing or design for manufacturability (DF) has been over the years, it has often been the case that DFM principles and methods necessary to really implement it have not been adopted. DFM is the process of pro-actively designing products to 1) optimize all manufacturing functions such as fabrication, assembly, test, procurement, shipping, delivery, service, repair etc. and 2) assure the best possible cost, quality, reliability, regulator compliance, safety, time-to-market, and customer service.[1] There are common reasons that generate resistance to DFM. Linear thinking and misconceptions about time are some due to which certain key decisions are postponed as they seem to involve others and to be not that important short term. Another key reason is that of not taking into account design constraints as early as possible. It is well known that a vast portion of a product's lifetime cumulative cost is determined by the time a product is designed. A formal understanding of the principles and methods of DFM can help generate awareness if lacking, and importantly enable successful DFM implementation and thereby deriving the benefits of DFM.

ROLE OF DFM IN THE CURRICULUM

The list of courses and requirements outlined in Table 1 shows that the curriculum has been designed with the intent of addressing the needs of students who are mostly in the technical and management workplace seeking a terminal degree, often cross-disciplinary. Many of them might have gained education and experience in specific areas of their speciality An understanding of DFM principles and methods can help them understand the importance of an integrated approach to design and manufacturing. This will enable them to contribute to or lead in implementing DFM in their practice.

MAJOR TOPICS PLANNED FOR COVERAGE IN THE COURSE

Design Methodology

> This section begins with an introduction to DFM, highlighting the background of DFM, the need for DFM, and the general approach needed for successful DFM. Specific principles and methodologies such as Concurrent Engineering, concurrent engineering design teams, empowerment, early consideration of design considerations / constraints, good product architecture, generation and use of DFM guidelines are then addressed.

Flexibility

It is often crucial for companies to have flexible manufacturing environments such as lean production, build-to-order, and mass customization. It is necessary to understand these environments and design for such manufacture. The section on flexibility addresses these aspects. In doing so, the student is made aware of key points to note in designing for flexibility such as the need to pro-actively planning product portfolios for compatibility with flexible manufacture, standardization, concurrent engineering of product platforms and flexible flow-based processes where feasible, minimization of setup, and modular design.

Cost Reduction

It is very difficult to remove cost through "cost reduction" measures after the product has been designed. Cost must be designed out of the product and production processes. The key to achieving the lowest cost product is to base all thinking and decisions on a total cost basis. This section on cost reduction addresses many aspects relating to the total cost approach such as cost elements, techniques to design low-cost products, total cost thinking and measurement, tools for total cost approach such as Activity Based Costing (ABC), and identification and control of cost drivers.

Design Guidelines

The application of the principles and concepts of DFM should enable the generation and utilization of design guidelines specific to each situation. This section helps in understanding design guidelines by providing general DFM design guidelines for assembly, fastening, motions of assembly, test, standardization, part shape, handling by automation, quality and reliability, and repair.

Besides the sections described above, the course addresses specific in-depth aspects relating to DFM such as reliability analysis and steps to implement DFM.

FACTORS TO CONSIDER IN OFFERING THE COURSE ON-LINE

1. **Working with information technology and on-line course management personnel**
   Teaching an on-line course requires a significantly greater amount of interaction with and support from information technology and on-line course management personnel. It is important for the faculty teaching the course to co-ordinate course requirements with such personnel in a timely manner to ensure that various resources and student activities are accomplished according to set plans. Examples include making on-line course content available as per study schedule and preparing exams /quiz in a timely manner to make them available on-line as per schedule.

2. **Getting trained in necessary online course offering and management software**

Although technical support personnel provide any necessary help, it is important for the faculty teaching the course to get trained in the on-line course offering and management software that supports the course. This can significantly enhance the productivity and effectiveness of the course.

3. **Scheduling course revision / development so as to synchronize with the release of the latest edition of the textbook planned for the course**
If course revision / development is not synchronized with the release of the latest edition of the planned textbook for the course, the revision / development will have to be repeated when the new version is released. As much of the course information must be in tangible form for an on-line course, such an approach is very likely to result in duplicated waste of significant effort.

4. **Structuring the content to be user-friendly and modular for easier revisions / modifications**
Modular structure of on-line content
* Provides user-friendly format for self-study by the students.
* Helps make changes easily to portions of on-line content as needed.
* Helps revise on-line content more easily for a new textbook or a new edition.
* Provides flexibility to enhance content quality and/or quantity more easily.

5. **Adapting multi-media course content to the on-line environment**
Limitations of on-line course offering and management software to handle multi-media course content must be overcome (by alternative means if required) to ensure that such multi-media content is provided on-line just as it is done in regular classroom situations.

6. **Conforming with copyright issues**
It is of course necessary ethically and legally to comply with copyright and confidentiality protocols. This can be quite a challenge given that students are in various geographic locations with access to information from various sources not only in the public domain but also in the private domain such as their workplaces. It is important to make use of administrative support that is often available to address such issues.

7. **Offering useful on-line teaching/learning tools**
On-line group discussion forums, e-mail correspondence, on-line announcements, digital drop boxes for assignment and submission of tasks, and on-line quiz / exams are some of the on-line tools that must support the core on-line content which is the primary source of learning for the students besides the textbook. The on-line quiz/exams help assess student performance beyond projects and take-home exams. Consistent with the on-line mode of instruction, assessment of how well the course goals' were met can also be assessed on-line.

CONCLUSIONS

This paper considered an overview of the on-line Master of Engineering program at UWP, background of Design for Manufacturability, the role of Design for Manufacturability in the curriculum, major topics planned for coverage in the course, and factors relating to the online mode of offering the course. The course is being developed by the author as part of the curriculum leading to a Master of Engineering degree at the University of Wisconsin - Platteville and is to be offered in the 2004 spring semester. The course fills the need for a course that addresses a concurrent and integrated approach to design and manufacturing through DFM principles and methods.

BIBLIOGRAPHY

1 David M Anderson, Design For Manufacturability & Concurrent Engineering, ISBN 1-878072-23-4, CIM Press, 2003.

BIOGRAPHY

Dr. P.B. Ravikumar is Professor of Mechanical and Industrial Engineering at the University of Wisconsin, Platteville. Besides on-line graduate courses in Systems Engineering Management and Design for Manufacturability, he teaches different undergraduate courses in design and manufacturing. He has over fifteen years of experience in engineering education and many years of direct and consulting experience in industry.