Int. J. Appl. Engng Ed. Vol. 7, No. 3, pp. 207–211, 1991
Printed in Great Britain.

0742–0269/91 $3.00+0.00

Design of a Lab Course on Computer Integrated Manufacturing*

S. K. VAJPAYEE†
G. A. SMITH‡
School of Engineering Technology, University of Southern Mississippi, Hattiesburg, MS 39406-5137, U.S.A.

Computer integrated manufacturing (CIM) has now established itself both as a concept and a technology. Its exploitation, however, is slow due to the lack of adequately educated/trained personnel. Colleges and universities are responding to this need by promoting suitable courses on and around CIM. Laboratory-based courses, however, are generally not offered because of the high cost involved in developing lab resources. In this paper authors illustrate that a lab course on CIM can be designed to teach its principles without incurring high expenditure. The salient feature of the design is that the course hovers around a typical manufactured product. A broad description of the complete course has been presented. One of the experiments, concerned with computer-aided design and drafting (CADD), has been discussed in detail. The way this experiment interacts with the other ones has been identified to illustrate the CIM philosophy.

INTRODUCTION

ENORMOUS changes are taking place in manufacturing due to advances in computer technology and worldwide competition. These are leading industry toward a global concept called computer integrated manufacturing (CIM). CIM is defined [1] as providing computer assistance, control and a high degree of integrated operation at all levels of manufacturing by linking islands of automation in a distributed processing system. Recent advances in technology suitable for soft automation are the stimulators for rapid changes in manufacturing. In the 1980s, CIM was just a concept, talked about [2] and discussed, but in the 1990s, it is a shop-floor reality.

Since CIM is becoming attractive to industry today, it is necessary that colleges/universities design and develop courses about the concept and technologies of CIM. At the University of Southern Mississippi, the graduate program in manufacturing technology is developing a laboratory-based course in this area. The aim is to reinforce students' understanding of CIM. By offering this course, we attempt to better educate our future manufacturing engineers/technologists who in turn would help industry adopt CIM. This paper describes and discusses the new course for the benefit of educators contemplating enhancement in their manufacturing programs.

* Paper accepted 20 November 1990.
† Associate Professor
‡ Research Assistant.

COURSE DESIGN

The MFG 670L: Advanced Manufacturing Lab has been designed as a one-semester two-credit-hour laboratory course in the manufacturing technology program. Assuming 14–15 weekly meetings during the semester, thirteen experiments, each lasting for four hours, have been planned. Each experiment concentrates on one aspect of CIM. Within the constraints of time and available resources, each experiment illustrates the principles, and its interrelationship with the other experiments.

Objective

The objective of this course is to integrate the knowledge gained by students in other courses of the program for the purpose of illustrating that manufacturing is a continuum. The MFG 670L lab, therefore, can be looked upon as a 'capstone' course. It is expected that the course would better prepare the student for the post-graduation job, thus contributing to the efforts of the employer in implementing CIM.

The candidate product

The course has been designed with some pertinent data [3] relating to a hypothetical company. A typical manufactured product has been selected as a candidate. The product, shown in Fig. 1, is a circular skill saw. This product was chosen since it is neither too simple nor too complex. Within the constraints of time and resources, we could not select a more sophisticated product. The selection was made judiciously to ensure that the product represents, as shown in Table 1, an array of components, materials, and manufacturing processes.

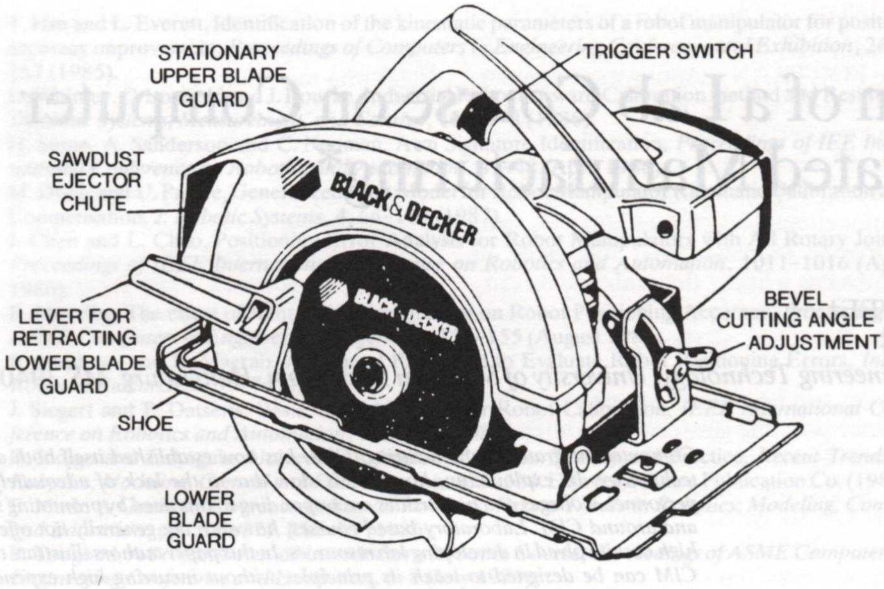

Fig. 1. Circular skill saw—the candidate.

Table 1. Component data of the candidate product

Part name	Number off	Material	Manufacturing processes
Blade guard	1	Plastic	Injection molding
Pinion gear	1	Alloy	Casting
Helical gear	1	Alloy	Casting
Snap ring	1	10XX steel	Sheering and punching
Hex head nut	1	10XX steel	Upseting and Forging
Gear housing	1	20XX aluminum	Casting

The product is amenable to easy disassembly, thus facilitating assembly/disassembly as and when required.

Contents

The course attempts to simulate a scenario within the CIM concept, thus experiments are design-oriented, and business-driven. Most of the experiments are patterned around a microcomputer since microcomputers are playing [3] an increasing role in CIM. Table 2 lists all the experiments and Fig. 2 shows how these interact with each other.

Experimental procedure

Each experiment has the following basic format (in bold).

(a) **Title**: Brief description.
(b) **Objective**: What is to be accomplished.
(c) **Assignment**: What does the student do?
(d) **Procedure**: How to complete the experiment.
(e) **Discussion**: Short questions centred around experiment.
(f) **Comments**: What did the student think

Table 2 List of experiments

Expt #	Brief title	Purpose
0	The Course	Introduction to CIM lab expts.
1	Business	Management and its link with other functions
2	CAD-1	Design and Analysis of a part, i.e. using finite element method
3	CAD-2	Drafting/drawing using AutoCAD
4	MRP-II	Computerized manufacturing resource planning and control
5	GT	Classification systems and coding of parts
6	CAPP	Development of a process plan
7	NC	NC code generation using NC programmer
8	FMS	Feasibility, design, and operation of FMS
9	Robotics	Feasibility and justification of introducing a robot
10	Simulation	Simulation of a process plan
11	CAQA	Design and implementation of a quality assurance program
12	MAP/TOP	Study of MAP/TOP as the nervous system of CIM

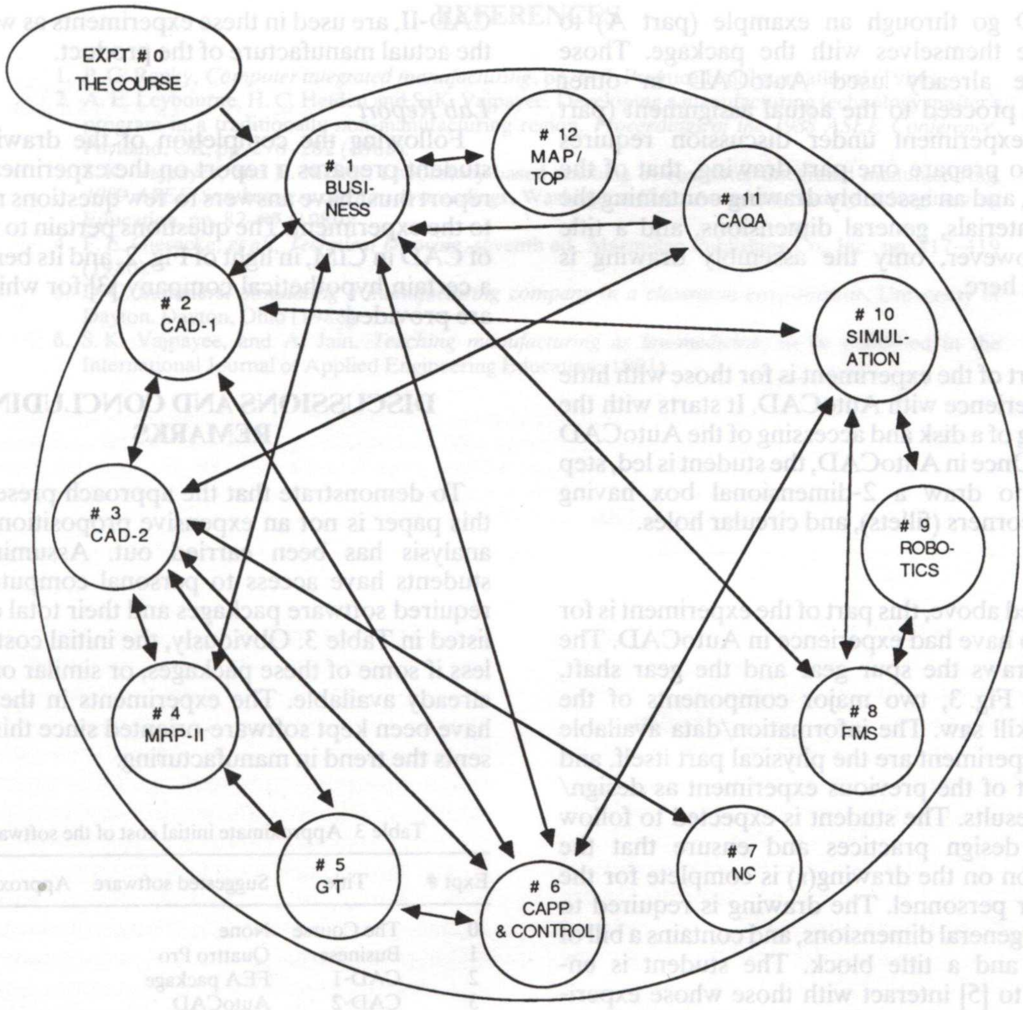

Fig. 2. Interrelationships among experiments showing CIM concept.

about the experiment, and how could it be improved.

(g) **Summary:** Conclusions drawn from the experiment.

A weekly report is completed by the student and turned in for evaluation at the beginning of the next meeting. Some experiments require outside research to supplement the learning in the class. Each experiment is worth 6 marks making a total of 78 (6 × 13) marks. The remaining 22 marks are allocated for the project discussed below.

Mini-projects

In addition to completing the experiments, students are required to carry out a 'mini-project' that covers in detail one of the thirteen experiments. The purpose of the project, chosen by the students in consultation with the instructor to avoid duplication, is to invite suggestions [3] as to how the experiment could be improved, and the cost of improvement. The student prepares a detailed report, and gives a presentation to the class on the last day. A successful completion of the project demands library research which benefits both the student and the course/instructor. The student develops creative skills, and the instructor gets some feedback from the consumer (the student) of the course for further improvement.

ILLUSTRATION THROUGH AN EXPERIMENT

To help the reader appreciate the learning within the course, one of the experiments (Expt. 3: CAD-II) is discussed below in detail. The description is concise in relation to that in the experiment handout.

Experiment 3: CAD—II

Design for manufacturability is the basis that links CAD with CAM, and with the other functions to achieve a CIM environment. The objective of this experiment is to appreciate the role of drawing in manufacturing, and to develop drafting skills using a CAD package. The design process involves drafting for which AutoCAD had been used. This experiment is complementary to Expt. 2: CAD-I, the focal point of most experiments in the course. It comprises two parts so that students new to

AutoCAD go through an example (part A) to familiarize themselves with the package. Those who have already used AutoCAD in other course(s), proceed to the actual assignment (part B). The experiment under discussion requires students to prepare one part drawing, that of the gear shaft, and an assembly drawing containing the bill or materials, general dimensions, and a title block. However, only the assembly drawing is illustrated here.

Part A

This part of the experiment is for those with little or no experience with AutoCAD. It starts with the formatting of a disk and accessing of the AutoCAD package. Once in AutoCAD, the student is led, step by step, to draw a 2-dimensional box having rounded corners (fillets), and circular holes.

Part B

As stated above, this part of the experiment is for those who have had experience in AutoCAD. The student draws the spur gear and the gear shaft, shown in Fig. 3, two major components of the circular skill saw. The information/data available for this experiment are the physical part itself, and the output of the previous experiment as design/analysis results. The student is expected to follow common design practices and ensure that the information on the drawing(s) is complete for the shop floor personnel. The drawing is required to show [14] general dimensions, and contains a bill of materials and a title block. The student is encouraged to [5] interact with those whose experiments have a bearing on his own, for example Expt. # 7.

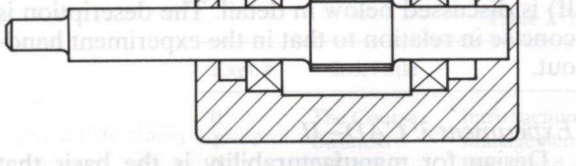

Fig. 3. Drawing of gear box assembly using AutoCAD.

As noticed in Fig. 2, the sample experiment (CAD-II) interacts with six other experiments. The data contained in the drawing (Fig. 3), the output of CAD-II, are used in these experiments as well as in the actual manufacture of the product.

Lab Report

Following the completion of the drawing, the student prepares a report on the experiment. This report must have answers to few questions relevant to the experiment. The questions pertain to the role of CAD in CIM, in light of Fig. 2, and its benefits to a certain hypothetical company [3] for which data are provided.

DISCUSSIONS AND CONCLUDING REMARKS

To demonstrate that the approach presented in this paper is not an expensive proposition, a cost analysis has been carried out. Assuming that students have access to personal computers, the required software packages and their total cost are listed in Table 3. Obviously, the initial cost will be less if some of these packages, or similar ones, are already available. The experiments in the course have been kept software-oriented since this represents the trend in manufacturing.

Table 3 Approximate initial cost of the software

Expt #	Title	Suggested software	Approx. Cost ($)
0	The Course	None	0
1	Business	Quattro Pro	275
2	CAD-1	FEA package	3000
3	CAD-2	AutoCAD	2500
4	MRP-II	STORM	3000
5	GT	GT package	1000
6	CAPP	CAPP package	3000
7	NC	NC Programmer	1500
8	FMS	Fischer-Technik	5000
9	Robotics	Minimover	1200
10	Simulation	SIMFACTORY	3500
11	CAQA	SQC package	1000
12	MAP/TOP	MAP 3.1	700
		Total	$ 25,875

In conclusion, this paper has illustrated how CIM can be taught in a laboratory environment, with limited financial burden to the manufacturing programs in colleges/universities. The course illustrates [6] the monolithism of manufacturing. The MFG 670L is a basis only; the experiments listed in Table 1 being just examples. Educators may modify/replace these to match the resources available at their institutions. Furthermore the course could be updated continually as and when new resources are acquired.

Acknowledgements—The financial support by the University of Southern Mississippi in the form of an assistantship to Geoffrey A. Smith, who helped in the development of this paper, is appreciated.

REFERENCES

1. P. G. Ranky, *Computer integrated manufacturing*, pp. 6–7, Prentice Hall International (1986).
2. A. E. Leybourne, H. C. Heiden and S. K. Vajpayee, Developing a manufacturing technology master's program in a traditionally non-manufacturing region, *Proceedings of the 1988 ASEE Conference*, Portland, OR, pp. 276–282 (1988).
3. S. K. Vajpayee, and E. Money, Laboratory-based teaching of computer integrated manufacturing, *1989 ASEE Southeastern Section Proceedings*, Washington D.C.: American Society of Engineering Education, pp. 82–87 (1989).
4. F. E. Giesecke, *et al.*, *Technical Drawing*, seventh ed., Macmillan Publishing Co., Inc., pp. 417–419 (1980).
5. D. C. Summers, *Simulating a manufacturing company in a classroom environment*, University of Dayton, Dayton, Ohio (1988).
6. S. K. Vajpayee, and A. Jain, *Teaching manufacturing as law/medicine*, to be published in the International Journal of Applied Engineering Education (1991).