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A Computer Integrated Manufacturing Major for Georgia Southern College School of Technology

Robert James Christensen

A COMPUTER INTEGRATED MANUFACTURING MAJOR FOR GEORGIA SOUTHERN COLLEGE SCHOOL OF TECHNOLOGY

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SCHOOL OF TECHNOLOGY

submitted by

Robert James Christensen

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CHAPTER I

OVERVIEW OF THE INVESTIGATION

Introduction.

One of the most significant advancements in modern manufacturing has been the introduction of computers into the industrial process. The computer has supplemented the human brain in nearly all aspects of manufacturing, enabling more work to be done at reduced levels of time and money. From designing products and testing them to controlling production and ensuring high levels of quality is what Computer Aided Manufacturing (CAM) is all about.

Unfortunately, these advances are in the infancy stage, for a major problem is that the vast majority of CAM systems are stand-alone systems, isolated from the rest of the factory environment. What is needed is integration of these systems to provide a way for the computer assisted company to oversee, guide, and control the entire manufacturing process from rudimentary design work to cost analysis and to packaging the final product. This is the theory of Computer Integrated Manufacturing (CIM).

What CIM does is tie together the CAM-based equipment into one complete, closed loop system, involving all the steps necessary to produce any given product with a common computer data base of information. This cohesive grouping of data enables the people managing the production system to keep on top of the process, and provides quicker turn-around times, whether it's redesigning or for restarting of a currently discontinued product line. However, CIM is not a system of "high-tech" machining centers and robots, it is a state of mind, not state of the art. The true form of CIM is where engineers, accountants, managers, and workers all share a common data base and a more effective line of communications. This makes for higher productivity, which is the most attractive feature of CIM due to its indefinite repeatability and information accessibility.

Statement of Problem.

A significant problem with "true" CIM technology is that it was not in practical existence as cited in advertising by IBM, InterCIM Corporation, and International Telephone & Telegraph at the date of this study, but the basic tools for its implementation were in use as small production cells in large manufacturing plants. This is most likely due to the large expenses incurred by this emerging technology. Unfortunately, this high start-up cost and complicated integration of systems has also put the vast majority of technology institutes behind in implementing CIM-style programs. Those that are introducing students to CIM are either highly funded research centers in which equipment is for use by researchers alone, or feature equipment that is actually a simple set-up of machine tools and a robot, erroneously referred to as CIM. The purpose of this study is to investigate the possibility of bringing "real world" CIM-based technology to the engineering/ technology student in the Georgia Southern School of Technology.

Hypothesis.

The hypothesis of this study is that by using current and proposed CAM-type equipment such as Computer Aided Design workstations, CNC machine centers, Robotics, and Computer Aided Process Planning software, together with a CIM-based curriculum that emphasizes business, software applications, and human relations, it is possible for the Georgia Southern School of Technology to become more effective in teaching fundamentals of Computer Integrated Manufacturing.

Basic Assumptions.

The basic assumptions for this study are as follows:

1. CIM technology shall proliferate as hardware costs go down.

2. The need for CIM-based technology and people trained in such shall increase due to demands on American industry to increase competitiveness.

3. The information gathered shall help provide students an opportunity to understand practical CIM systems.

Limitations and Controls.

The limits and controls for this study are as follows:

1. The study will be limited to current and future courses of study and equipment at Georgia Southern's School of Technology.

2. The production processes shall be limited to designing and machining small parts, and conducting manufacturing analysis on these parts.

Definition of Terms

The following terms are defined alphabetically as follows:

Computer Aided Drafting & Design (CADD). The use of computer graphics to provide an electronic medium for the drawing of production components.

Computer Aided Engineering (CAE). Engineering-based testing of a design by means of computer simulation.

Computer Aided Manufacturing (CAM). The use of computers to control any manufacturing process.

Computer Assisted Process Planning (CAPP). Planning the production sequence of a product with computer software.

Computer Integrated Manufacturing (CIM). The infusion of CAM systems into a single functioning system with a common data base.

Direct numerical control (DNC). A single or series of CNC centers that are controlled by a main computer, linked by a dual communications link.

Flexible Manufacturing Systems (FMS). A group of computer controlled manufacturing stations linked by a materials handling system and a common computer data base.

Group Technology. The systematic grouping of different products into related "families" by design or production technique.

Networking. The interconnection of two or more computers able to access common data and thus "communicate" with each other.

Robotics. Anthropomorphic manipulators controlled by a computer program for use in materials handling.

Many of the definitions and terms in this study are used throughout industry as "Three Letter Acronyms" (TLAs). These are fast becoming part of standard "technical English" of modern manufacturing due to their abbreviated form and supposed communicative ease. To the layman, not involved in manufacturing, all these abbreviations seem confusing. But, in order to become deeply involved in Computer Integrated Manufacturing, it will become imperative for students to become familiar with the "language."

Summary.

The need for providing technical students with a strong background in Computer Integrated Manufacturing is easily shown by the way that industry is turning to this innovative method of production. But rather then turn out graduates with experience and knowledge just in the hardware of CIM, it is imperative to give the CIM student an equal education involving the human side of Computer Integration Manufacturing, namely the business applications and human/technology interfacing. Without this "dual personality", Computer Integration of production systems is doomed to fail, as many nearsighted companies have unfortunately found out.

CHAPTER II

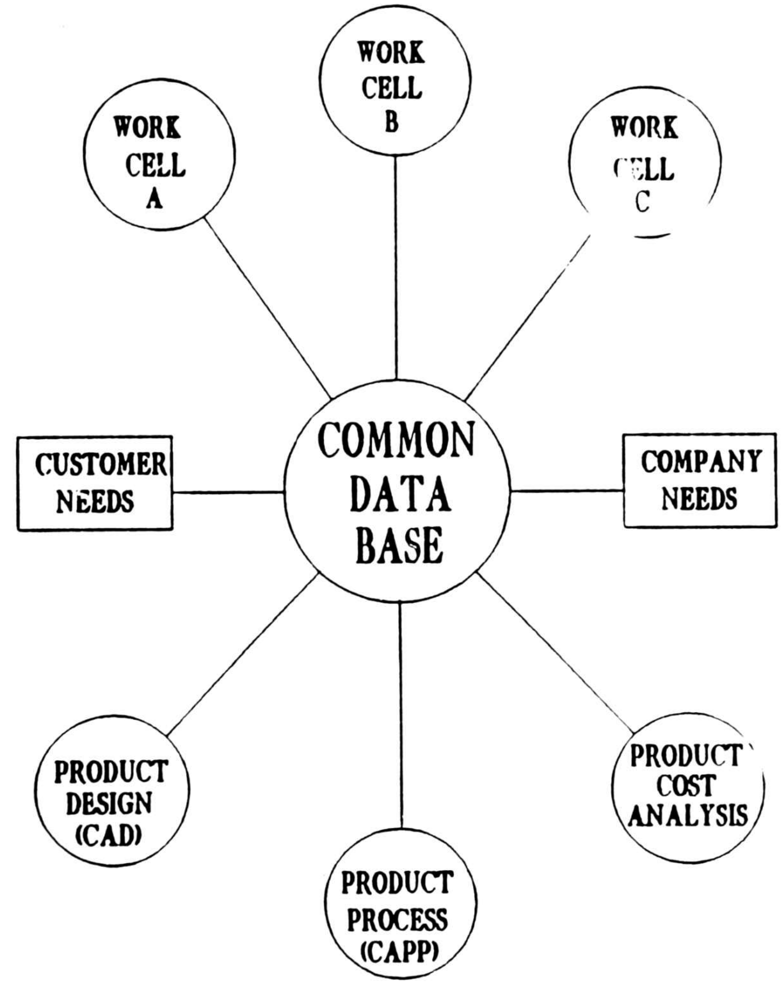
REVIEW OF LITERATURE.

Introduction

This review has been partially obtained from a review of books and periodicals on the subjects of CADD, CAM, and CIM. Also, material has been culled by the investigator from various academic lectures and hands-on use of CIM-style equipment at Georgia Southern College's School of Technology.

Computer Integrated Manufacturing is the combination of various computer controlled or assisted manufacturing systems and a common data base. This provides for a closed-loop manufacturing process system that can handle a variety of different applications and can use the same fixtures such as N/C machines, robotics, quality control system, scheduling, and process planning system, to complete each application with efficiency (39). According to William Beeby in New Advances in CAD/CAM, CIM and its two main components CAD and CAM, are simply "broad-based terms for the use of computers for design and manufacturing purposes and for communicating ideas and information." A simple diagram of a CIM system is featured in Fig. 1. At the 1986 CIMTECH Conference, sponsored by the Society of Manufacturing Engineers, Ken Branco of Codex Corp. (2) gave his ideas about what CIM was about. They were:

COMPUTER INTEGRATED MAUFACTURING



(FIG 1)

1) CIM is a total information system.

2) People, Policies, and Procedures are the basis of CIM.

3) It is a "Planned Synergy" between Engineering/Design, Factory Automation, and Manufacturing Planning and Control.

The idea of CAM was first thought of in the late 1950's at MIT when a milling machine was hard-wired into accepting limited programming (1). The theory of computer controlled machining took off in the '60s in the aerospace industry and when the minicomputer was developed in the late 1970's the final pieces of the CIM puzzle were coming into place. At a CAD/CAM seminar in Budapest, Hungary in 1984, the European team of Kochan, Jacobs, and Voclkner (18) came up with the following description of the ideal CIM system:

1. Autonomous work cells for designers and engineers linked by computer communication lines.

2. Availability to a common data base.

3. Computer interfacing for graphics, process planning, and design work.

4. Data transfer from process plan to machining centers, linked by direct numerical control.

Richard L. Simon (27) of Computervision had this thought on the role of CIM technology: "CIM encompasses many computer-based automation applications, a system whose prime inputs are product requirements and outputs are finished products. CIM is a fusion of software and hardware for product design, production planning and control, and for production processing". However, Anna Kochan and

Derek Cowan in Implementing CIM (1986), state that "Human motivation has as much influence over success or failure of CIM as does actual technology."

The best way to describe how CIM system functions is to follow an imaginary product going through the CIM process. First, the product is designed using a computer drafting system, capturing master dimensions (1). Then a product data base is created, getting as much product design information as possible (28). This enables a computer simulation program to perform any number of engineering tests on the design, without having to produce a prototype. If the design doesn't function according to its requirements, it is simply redesigned with no trouble.

The next step is converting the graphic design into a working process plan. In the CIM system, Computer Assisted Process Planning can produce process plans and generate machine codes for controlling production (5). The last step is actual production.

There are several methods of CIM-based production. One is having the process program sent to various stations on an assembly line. Another uses CNC machining centers to produce batches of a certain product. Computer Numerical Control centers are simply N/C machines with electronic brains. It uses data libraries to calculate machining parameters, tools, and to control the machining process (8). The last method is called Flexible Manufacturing, which is a system made of several machining or process centers tied together by computer and an automatic material handling system, and can produce as much as a 90 piece assembly line in less time (28).

The CIM system is completed by the computer communications network. This provides access to storage devices and valuable feedback concerning the entire system, such as scheduling and cost analysis. If one component breaks down, the system is halted automatically, and the malfunction is either corrected or an alarm is sounded for a worker to make repairs. A true distributed processing system is only as good as the network supporting it (28).

The reasons for converting to CIM are numerous. Richard Stover in An Analysis of CAD/CAM Application (30) writes; "CAD/CAM increases productivity and produces products that can be sold at reduced cost, in turn, creating more growth for the company". He also adds that "..the best use for CIM is to supplement human strengths and replace their weaknesses", continuing with "... it is best for Repeatability, Programmability, and speed along with safety."

A professor at Purdue University, T.C. Chang (5) notes that "..95% of all products are produced in lots of 100 or less". Futurist Alvin Toffler also recognizes this fact in his 1981 work, The Third Wave (37). Computer Integrated Manufacturing is the perfect media in which to conduct such production as it can produce these small lots with less time and cost in set-up than conventional methods (5). Beeby (1) also notes that "...difficult shop routines can be completed in fractions of the times used in the more conventional approach."

Summary.

In conclusion, it can be stated that in today's crowded and highly competitive world marketplace, the only way to successfully compete is to use every advantage that one has available. Computer Integrated Manufacturing is in a similar position that the Steam engine and the power loom had back at the start of the Industrial Revolution. Unfortunately, an estimated 30% to 40% of CAD/CAM systems fail due to misguided use by their users (28). To use CIM technology properly, one must go 100% behind its implementation and correct use. It is not just a new production tool, it is a new way of thinking about the total production system. Computer Integrated Manufacturing creates entire new relationships in a production organization, namely, knocking down the ancient walls of usually feuding departments such as Engineering/Design, Production Planning, and Finance (17). Those managers who failed with CIM were never really in the CIM frame of mind. They just thought of as CIM as "just some new machines." William Beeby (1) sums the situation up: "If American industry can effect practical, economical, and wide spread use of CAD/CAM, it can overcome the stagnant productivity that had caused the faltering of its credibility."

CHAPTER III

PROCEDURES FOR INVESTIGATION.

Introduction

The purpose of this study is to bring the basics of Computer Integrated Manufacturing in the classroom. By developing courses that involve all steps of manufacturing, students would be better instructed in how CIM technology can be best utilized in today's marketplace. The following is the intended path of research:

1. Compare and contrast Georgia Southern's current CIM-based curriculum with that of selected technical institutions from around the nation.

2. Determine what Industry requires in CIM and how post-secondary institutes live up to these needs.

3. Determine what type of current courses are best suited for CIM studies and devise possible new courses.

Current Course of Study in CIM at Georgia Southern College.

As of the time of this study, there were three major courses with emphasis in Computer Integrated Manufacturing technology:

1. IET 452 Robotics and Computer Integrated Manufacturing--A 5 hour class consisting of 3 lecture hours and 4 lab hours a week. Topics include fundamentals of robotics, programming, and a

brief look at CIM.

2. MT 450 Metal technology II-- An advanced metals course with 3 hours lecture and 4 hours of lab. Features instruction in metallurgy, numerical control programming, and computer numerical controlled machining.

3. TD 333 Computer Aided Drafting. A 3 hour course with instruction in CAD on the school's Intergraph system with usually only two in-class projects to be undertaken.

Further courses dealing with CIM-based technology include the introduction of students to CAD in the beginning drafting class, TD 150, and the various special problems courses in Metal Technology, Industrial Engineering technology, Industrial Management, And Technical Drawing. The three professors who teach these courses, Mr. Roland Hanson, Mr. Don Whaley, and Dr. Keith Hickman, respectively, also made up an Advisory Panel along with Dr. Earl Andrews. This panel met with the investigator and discussed the make-up of CIM and how the School of Technology at GSC could best provide instruction in it.

Current Level of CIM Hardware/Software.

With help from Gulfstream Aerospace of Savannah and Title III Federal grants, Georgia Southern's School of Technology is well equipped to provide students with experience in the many aspects of CIM technologies. First, there is the new Computer Aided Drafting and Design Lab, provided by Gulfstream Aerospace which features 17 Intergraph CAD workstations, which provides students with an expanded facility to learn CAD fundamentals. As of the date of this study, four courses were using this lab, these being the CAD classes, Introductory drafting, Production Drafting, and the Engineering Graphics classes.

In the School of Technology's Metals laboratories, there is a Hatachi-Seiki CNC VA-45 Machining center and a HT-20 Turning Center, both of which are equipped with conversational programming software. In addition there are three multi-post processing computers, a late model Numeridex and two IBM PC2s using the Nicam post processing program, along with a Multitoyo Coordinate Measuring Machine and a Hewlett Packard computer set-up for quality control work. The Robotics lab consists of two Rhino educational robots and five Fischer-Techniks Computer Integrated Manufacturing simulation models.

A Study of Computer Integrated Manufacturing College Programs from across the Nation.

A representative sampling of colleges and universities offering courses in CIM and identified with a summary of their course offerings is as follows:

THE SOUTHEAST REGION:

GEORGIA INSTITUTE OF TECHNOLOGY, Atlanta. Their program is a graduate interdisciplinary degree, for students from the Aerospace, Chemical, Civil, Electrical, Industrial/Systems, Computer, and Textile Engineering programs along with Management studies. There is no set curriculum, however, the program consisting of mainly independent research (12).

SOUTHERN COLLEGE OF TECHNOLOGY, Marietta, GA. Their CIM studies are in the MET department, consisting of five courses: IET 442 Automated Manufacturing Systems, MET 333 N/C Programming, MET 471 Advanced CAD/CAM, Met 435 Robotics, and MET 438 CNC/DNC. These courses add up to a total of 17 hours of MET optional elective classes (29).

EAST CAROLINA UNIVERSITY, Greenville, NC. The Department of Industrial Technology offers a B.S. degree in Manufacturing. Courses offered include Process Design (highlighting CAPP), Systems Analysis, Quality Assurance, metrology, and a required internship. Other than the Process Planning, no major CIM technologies are involved (9).

NORTH CAROLINA COLLEGE OF AGRICULTURE AND TECHNOLOGY, Greensboro, NC. NCA&T has both a department of Technology and Engineering doing some elective class work in CIM instruction. The Industrial Technology department has courses in Plant Planning and Management, Metrology and Quality Control, and two courses in Electromagnetic Controls. The Engineering side has Industrial and Mechanical Engineering courses in Robotics, CAM, and Project Management (20).

THE NORTHEAST REGION:

CLARKSON UNIVERSITY, Potsdam, NY. Here is an interdisciplinary program involved in each of Clarkson's five Engineering majors. Their CIM core consists of Statistics, Production Management, Engineering Psychology and Statistical Quality Control. The Industrial/ Mechanical departments asks for courses in Robotics, CAD, CAM, Manufacturing Systems and a management-based CIM class (6).

ROCHESTER INSTITUTE OF TECHNOLOGY, Rochester, NY. This school has a degree in Manufacturing Engineering Technology which has four technical core classes in CIM. These are; Introduction to CAM, CAD/Design, N/C programming, CAM II (A mix of FMS technology and Materials Handling.), Robotics, and Special Topics (24).

SUNY COLLEGE OF TECHNOLOGY, Uthica, NY. Here is an IET program with emphasis in either Robotics, IET, Manufacturing Engineering, and CAM-N/C. The Manufacturing Engineering electives are Robotics, Quality Assurance, Metrology, Manufacturing Control, Cost Analysis, and Lasers in Manufacturing. The CAM core is Measurements, Robotics, Manufacturing Simulation and Control, N/C and Compact II programming, along with a seminar in CAM (32).

CENTRAL CONNECTICUT UNIVERSITY, New Britain. They have a Manufacturing Engineering Technology program with major courses in Production systems, N/C, CAD/D, CAM, CAPP, and robotics, making up a basic technical CIM-style program (4).

THE MIDWEST REGION:

PURDUE UNIVERSITY, Lafayette, IN. There are two major programs here, one in the IE department and the other in the School of Technology. The Industrial Engineering program is strictly a graduate emphasis, being made up of three courses in CAM, Computer Process Planning, and Computer Modeling.

The School of Technology has a degree and department called Computer Integrated Manufacturing Technology. The coursework consists of 2 introductory classes and seven upper division classes in CAD, Simulation of Manufacturing, Sensor technology, Manufacturing Operations (statistics), Integrated Materials Handling,and Integration of Systems. There is also a senior project (23).

EASTERN MICHIGAN UNIVERSITY, Ypsilanti, MI. Here is a degree in Computer Technology with a Major in CAD or CAM. Courses include Introduction to N/C, Robotics, Process Planning, Controlling and Improving Manufacturing, Control and Instrumentation, and a Computer Aided Manufacturing lab class (10).

In the West Central region:

COLORADO STATE UNIVERSITY, Ft. Collins. A degree in Industrial Technology includes coursework in Electronic Control systems, Quality Control, CAD/D, Computer Industrial Electronics, Robotics and Flexible Manufacturing Systems, and Manufacturing Technologies (7).

TEXAS A & I UNIVERSITY, Kingsville. Here is an Industrial Technology program with no major CIM courses. The Mechanical Engineering department offers two courses in Industrial Electronics and Automated Production systems (35).

TEXAS INSTITUTE OF TECHNOLOGY, Lubbock. The department of Industrial Engineering has courses in Quality Assurance, Manufacturing Processes I and II, and Introduction to CAM, which includes topics on CAPP, N/C, and Robotics. The Industrial Technology program has no single course with CIM applications (36).

THE PACIFIC REGION.

STANFORD UNIVERSITY, Palo Alto, CA. Basically, Industrial Engineering material with three courses in CIM, process control, and advanced manufacturing simulation, but no hands-on type classes (31).

CALIFORNIA POLYTECHNICAL INSTITUTE, Pomona. There are Industrial And Manufacturing degrees, but very little in way of all-out CIM applications except for CAD/D electives (3).

EASTERN WASHINGTON STATE UNIVERSITY, Cheney. In the School of Technology, there is the Production systems major which has courses in CAD, Quality Control, Robotics and Automation, which includes Control systems and programming, as well as a Production Laboratory class (11).

Results of Manufacturing Survey by Independent Organizations

A study concerning the Georgia Southern manufacturing curriculum was conducted through the years by an outside, internationally recognized consulting firm from their offices in Atlanta, Georgia (26). Industrialists in the region acted as an advisory group and added input to the study. The object of this study was to determine the needs of industry and what could be the best possible manufacturing-based curriculum to serve those needs. The results of their study brought forth the following recommendations that affect instruction in Computer Integrated Manufacturing.

1. Graduates need more experience or knowledge in manufacturing technologies, processes, and procedures.

2. Engineering graduates need more instruction in business communication and human relations.

3. A student team progressing through a series of course "stages" would give graduates a better idea of how the typical manufacturing company functions.

A copy of this report is on file with the Industrial Technology Department of Georgia Southern.

Another independent group is the National Association of Industrial Technology (NAIT), which is the national professional organization that accredits post secondary Industrial Technology programs. Their national meetings provide the members an opportunity to attend interest sessions in which top industrial professionals discuss issues in industry and technology. One of the most important issues of NAIT discusses is the importance of modern computer aided manufacturing technologies, including CIM.

How CIM Functions in Industry

As opposed to the mostly solitary study of the college classroom, industry uses CIM in a team-based approach that includes persons from all levels of the production business, from managers, designers, accountants, marketing personnel, industrial and manufacturing engineers, to individual workers on the factory floor. There are no all-encompassing CIM experts in industry. Instead, there are the business-application personnel and the technical staffs who work together. This cooperative effort contrasts with the four year individual work found in the colleges and universities. Apart from a few team projects utilizing 2 to 4 members, the vast majority of time spent in school is in direct competition with other students for grades, especially in courses in which grades are assigned by statistical curves. In the classroom, sharing information can be detrimental to one's grades, and could even be considered "cheating." However, in the working world, there is nothing wrong with sharing information with fellow workers, which is vital to a business's very survival. This "spreading of the information" is the main aspect of CIM. Of the seventeen sampled institutions, only Georgia Tech, Clarkson, SUNY College of Technology, and the Purdue School of Technology had any major CIM-based courses taught in strictly student team fashion (12,6,30,23).

A look at the Technical Employment section of any Sunday newspaper shows many manufacturing firms seeking mechanical or electrical engineers for manufacturing-based positions such as designers, process/control managers, and facilities planners. But do such engineering students have the applied manufacturing-based skills necessary for industry? According to another participant in the Manufacturing Technology Curriculum survey sponsored by Georgia Southern (26), "Graduates coming into the marketplace today lack management skills or manufacturing expertise." Another stated: "We need college graduates who are familiar with the concepts we now train in quality, human resources, statistics, etc." (26). When asked about a proposed Manufacturing Management degree at GSC, one respondent concluded: "A degree program in manufacturing would help a student and company bond together much quicker." (26).

Review of Above Research.

An examination of the above institutions revealed one major fact that laboratories are needed to provide hands on experience for students in addition to regular lecture classwork. The majority of the engineering schools do not have these labs nor do they have designated CIM degree programs. Rather, they are interdisciplinary degrees or graduate level research programs. A participant in Lewis Selvidge's study stated: "Traditional Engineering Schools do not give an in-depth, practical approach to the problems and solutions relevant to the manufacturing environment." Likewise, a number of the Industrial Technology schools are still encased in the traditional vocational technology style education system. Noting the increase in CIM-based courses, a few have developed programs of study that have CIM applications in mind, but even these are apparently mesmerized by computerized machine tools by their emphasis on technical classes shown in their course catalogs. This is forgetting the "soft," human relations side of CIM that is instrumental in its final success- the ability to use computer networks for production-based information exchange.

CHAPTER IV.

RECOMMENDATIONS FOR A CIM-BASED CURRICULUM.

A Plan for CIM at Georgia Southern College.

The two most important aspects of Computer Integrated Manufacturing education are: (1) familiarity with manufacturing technologies and process; and (2) the ability to work with both computer technology and fellow students effectively. This is a problem that involves engineering studies, engineering technology, and the industrial technology departments. The engineering student is for the most part able to work well with computers and student teams, but is at a loss for simple drafting and industrial process knowledge, such as tolerancing or machining techniques. On the other hand, the engineering technology and industrial technology students are given a grasp of the physical aspects of manufacturing but are often not able to understand fully the team idea in business or the full use of computer communications. The need in the total CIM program is to strike a balance between technical expertise and the ability to work with others. Kochan and Cowan (18) stated that "Planning (CIM) is exploratory and analytical while Design and Implementation is more technical." This shows that students need to know the holistic theories of what communicative power CIM has, at the same time having a solid technical background to back up the sociological portion of this production philosophy. Any type of Computer Integrated Manufacturing studies at Georgia Southern would have to abide by dual personality of CIM in order to properly educate the much needed future manufacturing technologists. Therefore, human relations courses will be just as important as the actual hardware-based technical courses. Existing "humanist" courses already offered at GSC are Industrial Supervision, Technical Writing, and Industrial Psychology. A further look at the Human side of CIM would be found in hypothetical course of the same name, in which student teams, already familiar with the technical CIM fields such as CNC and CAD, would learn how to use both these technical applications along with managerial and business-based functions found in today's modern industrial world.

Recommendations for a Computer Integrated Manufacturing Program at Georgia Southern

In order to better educate students in the basic fundamentals of Computer Integrated Manufacturing (CIM), it would be necessary to change the current curriculum of the Industrial Technology program. A new "major" could be added called Computer Integrated Manufacturing Technology. In order to fully take advantage of this new major, older courses would have to be altered and new ones created to present the student with all the aspects of CIM.

TABLE 1

A LISTING OF CURRENT AND PROPOSED COURSES IN COMPUTER

INTEGRATED MANUFACTURING AT GEORGIA SOUTHERN.
(C)=Current (P)=Proposed

General Technology Courses

Industrial Processes.(C) A survey of manufacturing materials and basic processes. Five hours credit.

Robotics. (P) This is an in-depth look at robotic systems with 3 hours lecture and 4 hours of lab work. Students will be able to understand the fundamentals of robotics and also be able to program a robot to perform a certain function. Five credit hours.

Computer Aided Manufacturing Systems. (P) A senior level class dealing with the more technical aspects of CIM-based systems and processes such as CNC, CAQ, CAPP, and DNC. Students in a team-type situation will learn the theory of CIM and design and program a simple CIM simulation system. Three hours lecture, 4 lab hours. 5 hours credit.

Computer Integration of Manufacturing Systems. (P) A more advanced course, this transcends the technical part of CIM and develops the student's sense of the business/social frame of Integrated systems as opposed to the more technical hardware. Students go through the entire procedure of design, cost analysis, and production as one team, better understanding CIM's communication and coordinating ability through the use of interactive software. Five hours lecture/lab for 5 credit hours.

Industrial Engineering Technology Courses.

Industrial Safety. (C) A look at Safety practices and procedures in modern industry. Two Credit hours.

Material Handling Systems. (C) A survey of tools and techniques of efficiently moving and routing material and finished products. Two hours of lecture/lab.

Time and Motion Studies. (C) A practical exploration of production efficiency techniques. Three credit hours.

Computer Aided Process Planning. (P) An exploration of the many different types of Computer process planning techniques. Students will be given several manufacturing problems to solve using CAPP. Five hours credit.

Production Facilities. (C) Plant Layout using computer aided design techniques. Students will be able to design a production facility and its necessary utilities. Three hours lectures, 4 hours lab/extended lecture.

Engineering Economy. (C) A survey of economics in the manufacturing and engineering fields. Five hours credit.

Industrial Management Courses.

Introduction to Industrial Management. (C) Five Credit hours.

Quality Control Systems. (P) A look at the need for Quality

Control, the use of statistical QC and Computer Aided Quality (CAQ). Five hours credits of lecture/lab.

Industrial Psychology. (C) A look at psychological factors in production areas and productivity. Five hours credit.

Industrial Supervision. (C) Five hours credit.

Metal Technology Courses.

Metal Technology I. (C) Basic machining and metallurgy. Three lecture and two lab periods for five credit hours.

Metal Technology II. (C) Computer Assisted machining techniques and advanced material processes and metrology. Students will be able to understand briefly the CNC equipment available at GSC. Three hours lecture, Four hours lab/extended lecture for five hours credit.

Technical Drafting Courses.

Basic Drafting with CAD. (C) Same as normal drafting, but with no paper. Student will learn fundamentals of drafting technique, proper design and an introductory look at and usage of the School of Technology CAD/D system. Three hours lecture/ 4 lab/extended lecture for five credit hours.

Advanced Computer Aided Drafting and Design. (P) More advanced CAD work plus manufacturing design and a brief look at Computer Aided Engineering and Analysis. Three hours lecture/ 4 hours lab for five credits.

Production Graphics. (P) Production drawing, design, format, and procedures used in the work place, including Group Technology and cost analysis. Five credits for 3 hours lecture/ 4 hours lab.

To make a total number of credit hours equal to 190, there will also be the additional courses of Digital Computation, Descriptive Geometry, Statistical Analysis, Accounting, Technical Writing, and the Manufacturing Industries course. Also, there will be a requirement for a student to take a special problems course in Metal technology, Industrial Engineering or Management, Drafting & Design, or General Technology; depending upon the student's preference. For example, a student more interested in robotics could take a special problem course and plan an individualized project involving a specific application of robotics. A sample schedule is shown in Fig. 2.

A SUGGESTED TECHNICAL COURSE SCHEDULE OF CIM STUDIES AT GEORGIA SOUTHERN COLLEGE

YEAR 1	TECHNICAL DRAFTING MANUFACTURING ENTERPRISE
YEAR 2	COMPUTER AIDED DESIGN MANUFACTURING PROCESSES INDUSTRIAL MANAGEMENT ACCOUNTING PRINCIPLES
YEAR 3	METAL TECHNOLOGY I QUALITY CONTROL STATISTICS ROBOTICS PROCESS PLANNING TIME & MOTION STUDY PRODUCTION DRAFTING & DESIGN
YEAR 4	METAL TECHNOLOGY II PLANT LAYOUT SAFETY COMPUTER AIDED MANUFACTURING SYSTEMS COMPUTER INTEGRATION OF MANUFACTURING INDUSTRIAL SUPERVISION SPECIAL PROBLEMS

FIG. 2

The most important courses in this proposal would be Computer Aided Manufacturing Systems and Computer Integration of Manufacturing. A Computer Aided Manufacturing course would provide the student with a working understanding of the more technical information required by today's manufacturing-based engineers, technologists, and managers. This would also give the student a strong working experience with such equipment, enabling the future graduate to assimilate into the work place easier. A Computer Integrated Manufacturing course would give students practical experience in the exchange and manipulation of business information of modern manufacturing, on a smaller scale. Here student teams would design a product, for example, a wheel hub, with a CAD program, devise a process plan, and then produce the parts using the CNC machining centers, all on a short time frame. The actual production would be an integral part of this course, but the main emphasis would be on the interaction of different departments. This last class would make up for the absence of such non-technical instruction found in most of today's institutes of technology.

The Student Project for the CIM Major

An important aspect of the proposed Computer Integrated Manufacturing degree at Georgia Southern will be the Independent student project. This will be a technical project based on the interest of the student in the wide field of computerized manufacturing. Any applicable topic can be chosen; robotics, CNC programming, CADD, or Group technology are some examples. In order for a student to take the Special Problem course of their choice, they would have to have senior standing, and have approval by an advisory professor, who will work with the student by providing academic and technical guidance.

In order to provide a more detailed description of the project, a hypothetical project shall be discussed. The student selects a project topic in Group technology. The student will seek permission of their academic advisor by submitting a plan of study the quarter prior to the project. The student then formulates the type of part to produce, the different members of that part family, and then designs and machines those parts. This provides a student with knowledge in a CIM field not normally taught. Other specialties would include production scheduling, more advanced robotic and material handling systems, or just more intense work in CAD. The special project enables the technical student to master a specific area of CIM, making for a more desirable applicant for an industrial career and the School of Technology would be producing excellent technical CIM students at the same time as introducing students to what they would be expecting in the modern manufacturing industry.

Summary of Proposed Curriculum Changes.

This new program in the school of Technology will provide the student with a challenging, but rewarding educational experience in the field of Computer Aided Manufacturing, by providing a solid basis in both the technical, business, and human relations skill needed for their future in Computer Integrated Manufacturing applications in tommorow's Industry. The student receives the fundamental technical courses in both the Design and Production areas, and also will be exposed to the equally important "humanistic" area of technical management and inter-company communication. This would transcend the simple, "all-technology" CAM labs offered by other Industrial Technology schools. Instead the student would receive both the humanistic and technical skills, and confidence to work with machining centers, robots and the other computer controlled manufacturing equipment without the extraneous engineering courses not used on the actual factory floor such as statics, thermodynamics, or calculus (26). What is most needed is the ability to understand and properly use the fundamentals of Computer Integrated Manufacturing.

Additional Equipment Needed to Further The Georgia Southern CIM Program.

Just as important as the proposed curriculum changes are additions to the hardware collection already in place at Georgia Southern. Currently, the School of Technology is like many of today's manufacturers; the necessary equipment is in place, but they are in "islands of technology". Namely, that in order to achieve CIM, they must be connected and be able to communicate with each other. In order for students working at the various computer stations to send data to either robots or CNC centers, there must be that interconnecting software and hardware. This presents the need for CAD/CAM interfacing programs and fiber optics cables. This entails the communications aspect of CIM, which provides data access to designer, production engineer, accountant, and company president. Also, there is a need to upgrade existing computer software in the part processing, quality control, and for scheduling aspects of CIM, menu-driven interactive maufacturing software. The only major expenditures would be for the personal computers, a small Flexible Manufacturing workstation, and additional space on the Georgia Southern Computer system for the Manufactucturing Data Base. The cost would be considerable, but in the long run, quite beneficial to GSC and the local economies.

CHAPTER V.

CONCLUSION

Computer Integrated Manufacturing and its brethren CAD and CAM are today's equivalent of Watt's Steam Engine and Ford's Model T assembly line, the third phase of the Industrial Revolution (35). Not to see this as the wave of the future would well be today's equivalent of the Luditte movement, which vainly fought the introduction of "high technology" into the workplace in the 1790s and early 1800's. Computer Integrated Manufacturing must be accepted as the newest philosophy in production. Those individuals who do not move into CIM will be going the way of the 17th century hand loom operators.

The most important aspect of incorporating CIM fully into the work place will be educating the new engineers and technologists who will be depending on this innovative technology for their livelihood. Tomorrow's technical manufacturing professionals will need to know as much as possible about the technical innovations of Computer Integrated Manufacturing, such as its technical component like CAD, Flexible Manufacturing Centers, Computer Post Processing, Computer Aided Quality Control, and Robotics. It is also important to know that Computer Integrated Manufacturing is an organizational innovation of binding together such production facets as scheduling, accounting, and business planning. Today's student must learn the basic theories and processes of manufacturing and how to function with others in a company using CIM's informational exchange usage. If not, the attempt to implement CIM in America will continue to fail.

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