AC 2008-1978: MANUFACTURING ENTERPRISE SIMULATION AS THE FOUNDATION COURSE AND SYNERGISTIC FOCUS OF ADVANCED COURSE HANDS-ON APPLICATION

Phil Waldrop, Georgia Southern University

Dr. Phil Waldrop earned his Ph.D. from the Purdue University School of Technology. His industrial experiences range from turret lathe operator to Director of Advanced Process Development. His 11 years of aerospace R&D work included metal matrix composites and high speed machining, and responsibilities as Manager of Manufacturing Technology and Industrial Modernization technology development projects management for the B-2 aircraft program. He has performed invited service in an endowed chair as Stocker Visiting Professor of Engineering & Technology at Ohio University, and formerly taught at the University of North Texas. Currently a Professor in the Department of Mechanical and Electrical Engineering Technology at Georgia Southern University, he teaches courses involving metal forming, plastics/composites, lean manufacturing, and industrial/environmental safety, along with a manufacturing enterprise simulation course for which he co-authored the text and was presented a 2004 Leavey Award for Excellence in Private Enterprise Education. He is faculty sponsor of student chapter S85 of the Society of Manufacturing Engineers, has chaired two SME senior chapters and currently is a member of the SME International Director/Member Council Nominating Committee.

Title of the Paper:
Manufacturing Enterprise Simulation as the Foundation Course and Synergistic Focus of Advanced Course Hands-On Application

Abstract

This paper describes the effective utilization and benefits of a hands-on laboratory-based production enterprise simulation course as the introductory foundation for subsequent IT or IET program major courses.

Using the Georgia Southern University B.S.-Manufacturing degree program's nationally-recognized enterprise course as a model, the following key outcome-oriented benefits will be presented: "big picture" understanding of the industrial enterprise as a system; provision of a common base of experience which provides motivating synergy of upper-division course content; and a functioning production operation providing the capability to apply time studies, plant layout, lean concepts, tool design, ergonomics, automation and related studies in a tangible, hands-on basis to enhance major courses.

Background

At Georgia Southern University, the undergraduate course "TMFG 2131 - The Manufacturing Enterprise" was established in 1970 and has been utilized since to provide thousands of students with a synergistic insight to the organization, interrelationships, and tasks of the diverse functional elements of a business enterprise. In so doing, it has received national recognition three times, first in 1983 by the Society of Manufacturing Engineers, and most recently the 2004 Leavey Award for Excellence in Private Enterprise Education, presented by the Freedoms Foundation at Valley Forge, which included a $7,500 cash award to the instructor.

The Manufacturing Enterprise course provides a hands-on activity-based simulation that involves each student in the roles of management, marketing, and production. A "factory" laboratory facilitates the manufacture of a product for actual profit which is divided among the students on a per-share basis.

The course attracts students from around campus who take it as a requirement for certain other majors, or as a preferred elective recommended by College of Business program academic advisors, or as a career exploration opportunity in that most popular major, "undecided". A number of undecided students - and others who switched from a major outside the department – have been recruited as a result of their Enterprise experiences and concurrent exposure to the engineering technology and industrial technology academic programs.

The primary purpose of the course, however, has been to serve as an introduction and foundation experience for new majors in the NAIT (National Association of Industrial Technology)-accredited manufacturing degree program[1], a unit of the Department of Mechanical & Electrical Engineering Technology. This baseline of manufacturing industry exposure, and the production

laboratory facility itself, are essential resources for subsequent upper-division technical courses, which purposefully use the students' shared Enterprise knowledge and applied experiences.

"Big Picture" Enterprise Insight

A key benefit of the Manufacturing Enterprise course is that it provides a clear understanding of how the various engineering, technology, and business functions comprising a typical production department relate to each other and to the seven other functional components of the total company (Figure 1).

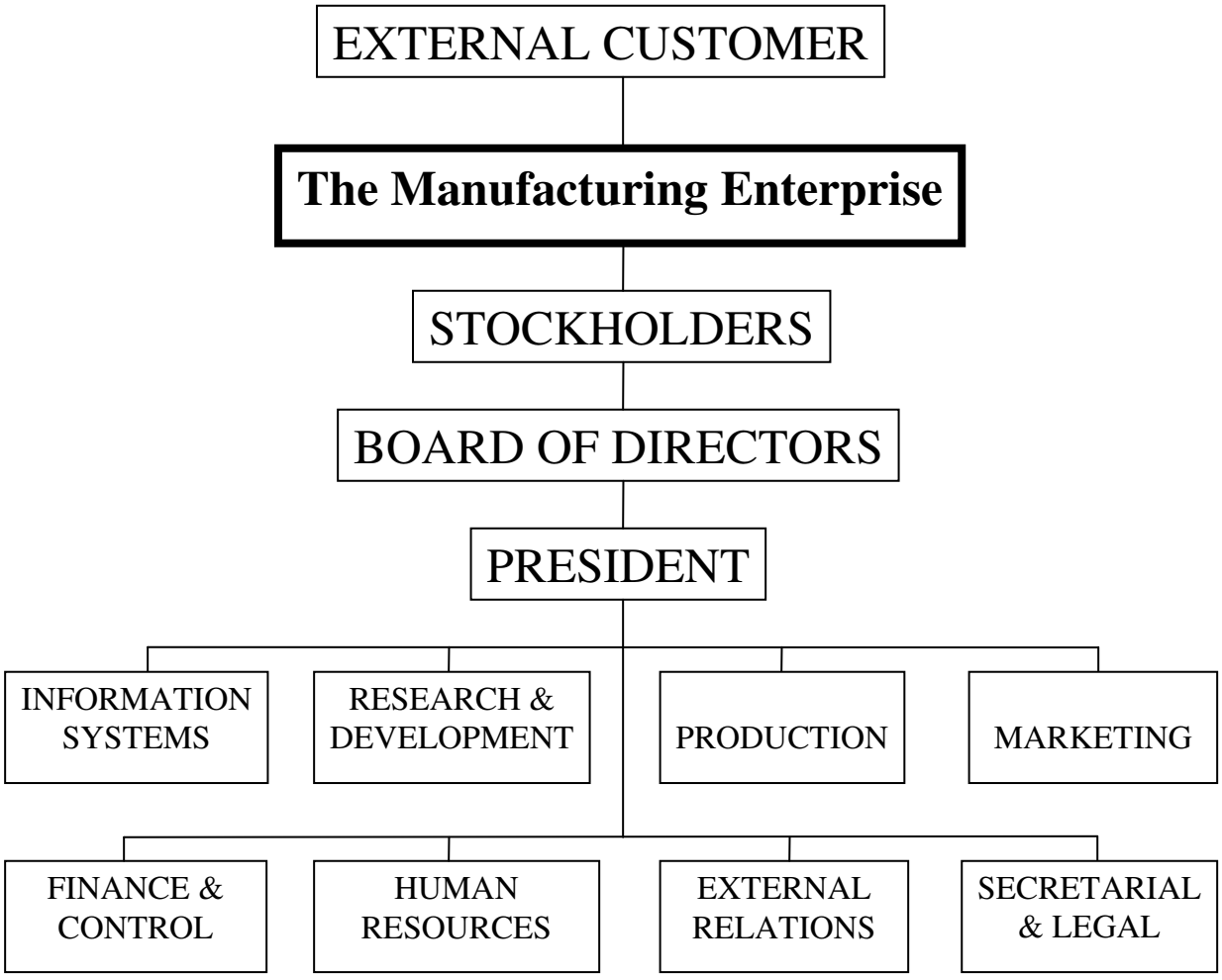

Figure 1: Enterprise Organization[2]

Such an understanding is important in good part due to nature of and need for the cross-disciplinary teamwork that is critical for success in contemporary global business. In discussing the field of operations management, Chase, Jacobs, and Aquilano[3] emphasize Tom Peters' view that whether the teamwork involves so-called pure, functional, or matrix projects, the cross-functional nature remains.

In the Manufacturing Enterprise course, students study the twenty-eight standard divisions that comprise the eight standard departments depicted above. In total, students are responsible for leadership and task-oriented management of these thirty six departments and divisions, plus the lead role of president. This authenticity of this standard organizational structure is defined by the Association of Consulting Management Consulting Firms, Inc. (AMCF, Inc.), and is covered by the scope of the locally published, course-dedicated text written and continuously updated by the program faculty with primary responsibility for the creation and teaching of the course over the years.

Among other notables, Dr. Richard Schonberger, president of Schonberger & Associates, Inc. has directly provided endorsement of the faculty-authored course text. "This innovative textbook and simulation guide provide a realistic way for students to experience a full set of business functions without leaving the classroom. It effectively fills a large hole in business studies"[2 (p. i).]

The importance of cross-disciplinary teamwork may be seen in an example of the critical path schedule in product time-to-market:

- Profits cannot be banked until sales begin; sales cannot begin until pricing is established;
- Pricing is defined through use of a financial break-even analysis that cannot be performed without input of direct and indirect expenses.
- None of this can occur without Production Planning and Control input that depends on Product Engineering specifications and subsequent Purchasing research on materials and part costs.

Motivation

The pragmatic "learning by doing" educational philosophy of John Dewey (1859-1952) continues to be highly relevant today. One is not as motivated or as able to learn a sport or career skills through books and lecture alone. The merits of simulation are presented in numerous papers presented at recent ASEE conferences. In one such paper[4], the authors quote ABET 2000, stating, "graduates must be able to measure manufacturing process variables in a manufacturing laboratory and make technical inferences about the process." Most of the simulation presented in ASEE papers is, of course, computer-based, and there are many merits to that format. In many situations, computer simulation may reduce time, costs, and other factors, especially in actual engineering research and design.

For the classroom, the literature of various technical fields[5,6] indicates that there often is no significant difference between "real" and computer simulation lab experiences in the learning of technical content. However, a real hands-on lab with real, tangible equipment, tools, processes and products may serve as a significant complement to both traditional and computer simulation. A key benefit involves motivation. David Heise, in describing initial observations and subsequent learning research focused on his Computer Architecture course at Columbia (MO) College, noted that "the physical laboratory seemed to be much more successful in enhancing the learning of the students"[7, p.105] than did computer simulation. Heise further states "feedback that reflects the level of a student's understanding is particularly valuable, leading to metacognition, or a self-awareness of one's state of understanding. Debugging a circuit is a wonderful example

of this, and in many instances debugging a breadboard circuit provides a much richer experience than clicking a mouse on a computer screen at various points to determine the correctness of a particular circuit. Motivation plays a significant role in the amount of effort a student puts into a task. This in turn leads to a greater amount of time spent on the task, as well greater interest in learning a particular subject matter."[7, p.106]

At Georgia Southern, Manufacturing degree majors along with students of MET, InfoTech, accounting, marketing, graphics production, apparel design, athletes in General Studies, and other majors are motivated during the Enterprise course for several reasons. Enjoyment of the hands-on production work - that includes injection molding, machining, finishing, and assembly – and receiving an actual check of possibly $100 or more on final exam day – are obvious factors. Of course, they often purchase one or more of the finished products.

More importantly, they carry this mutual experience forward as they take courses such as Plant Layout, Productivity Measurement & Improvement, Production Planning, and World Class Lean Manufacturing. In these courses, faculty members not only refer back to the Enterprise experience in lectures, they bring the students back to the lab for motivating, hands-on application of theory and practice.

Of substantial synergistic importance to the academic program, students are able to directly conduct time and motion studies, make observations of processes, equipment, tooling, and the quality of the product output. There are hands-on opportunities for product development, tool and machine design projects, automation applications, fool-proofing devices, flow improvement, kanban systems, visual workplace design, statistical process control, materials handling studies, and ergonomic, safety, and industrial hygiene analysis, among other applications. Such opportunities make a clear difference in an applied technology program.

In addition, the enterprise simulation lab is available for undergraduate research projects and for fund-raising projects that may be pursued by the program's student chapter S085 of the Society of Manufacturing Engineers.

Operation

The enterprise simulation lab utilized by the Manufacturing degree program at Georgia Southern has matured to become a focused factory that produces different models of a very popular proven product, wall clocks with the official university logo (Figure 2). In past years the classes brainstormed and developed a substantial variety of their own new products, but this diversity was seen as an impediment to provision of a contemporary product-focused factory approach in contrast to the former "worst case" process-oriented layout with its various "non-Lean" wastes.

The R&D department (research, product development, and product engineering divisions) student managers pursue appropriate product variations or process-oriented projects each term. The reduced emphasis on new product development has permitted a greater focus on the manufacturing elements that are more closely tied to the goals of the curriculum.

The clock products involve a combination of purchased components, supplies, and raw materials. The main parts produced in the factory lab are wood clock faces, plaques, and pendulum subassemblies, all of which are produced on a JIT basis, realistically blending anticipatory and order-based scheduling as in the Toyota Production System. Wood is an attractive material and a renewable resource, and the required equipment is inexpensive. Production tooling minimizes the need for skill or setup knowledge, and enhances safety.

Figure 2: Examples of Enterprise products for sale

Figure 3: Manual pin routing using a CNC-machined jig

Figure 4: Application of lacquer finish

During a 15-week semester, the students elect a Board of Directors (Figure 1), with the other students serving as division managers under VPs. Stock sales are initiated. Operating budgets are established, material costs researched, and token-level wage and salary rates are defined. The Control division develops a break-even analysis and, with Sales Planning, leads a formal vote on the product pricing structure. Brochures, receipt and order forms are printed, the web site is updated, and sales begin. Sales Operations accepts orders and payments. Finance deposits the funds into an actual checking account, and Production Planning & Control requisitions materials from Purchasing and receives and conveys JIT production orders. A "pull" system serves the internal supply chain of the parts, finishing, and assembly cells. Tested products are delivered to the customers and profits are distributed on a per-share basis.

Summary

The Enterprise course does not teach "woodworking"; the current products and processes were developed mainly on the basis of equipment on hand in decades past. However, for any college program – especially an ET program - wanting to implement an enterprise simulation lab factory, many other products and materials/processes, such as plastics or metals, could be selected. Some products might be promotional/recruitment items for the program. For that matter, the product could be screen-printed tee shirts or chocolate chip cookies.

The extent of automation is also an open issue. In any case, having an actual production lab provides a variety of opportunity for hands-on applied study of tooling, machine controls, statistical process control tools, and systems integration.

While it is not the intent of this paper to promote the adoption of the textbook used in Georgia Southern's Manufacturing Enterprise course, it is available as a basic resource and has the advantage of being controlled by the faculty authors and locally published in soft-bound fashion to facilitate continuous revision and customization. Each chapter contains - in addition to essential topic content - a simulation guide that lists the typical management tasks, and a complete set of standard management forms for operation of the departments and divisions. PowerPoint lecture and test materials are also potentially available.

In conclusion, it is hoped that other IT and ET faculty will recognize the unique merits of a production simulation course, and a factory laboratory that actually goes beyond simulation by producing a product that may be marketed.

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