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Introduction

To meet the growing need for Ph. D. technology management graduates, seven universities created a consortium in 1998 to better reach a wider constituency. Presently, the coverage area includes the mid-west states of Ohio, Indiana, Missouri, and Wisconsin, and the southern states of Tennessee and North Carolina. The program maintains most of the traditional requirements of advanced graduate study, but stands as unique in its use of the broad resources of its seven consortium members. Of further importance, each university offers a distinctive philosophical attribute and extensive library holdings that add depth and quality to the program. The schools are linked together by alternative communication systems, primarily relying upon web-site instruction. Classes for the degree include ten general core courses in research, statistics, philosophy, etc. and ten courses in one of five specialty areas; Construction Management, Digital Communications, Human Resources Development and Management, Manufacturing Systems, and Quality Systems. The program has clearly demonstrated that a web-site based consortium approach can more effectively deliver a Ph. D. level degree program to a wider audience than other more traditional strategies. However, what was initially gained in the effectiveness of outreach was lost in some instances in the vastness of the system.

One major pressing concern, which emerged, was the problem of establishing some level of agreement among consortium professors regarding what might constitute a core base of knowledge. In this regard, the consortium was not alone. Sinn and Olson have recently addressed this urgent problem as it relates to the field of industrial technology in general. Specifically, they argue, "what industrial technologists do and how they should be taught are fundamental issues... technology is a discipline, its boundaries and content should be defined" (Sinn & Olson, 2001, p.2). The problem, Sinn and Olson lament, is that "there are as many views on content, curriculum, and instruction as there are technology programs" (p.2). Patrick and Zargari (2002) have noted in this same regard that one of the prime reasons for research and scholarship among professors in the field of industrial technology in general should be to carry out studies which help leaders "to understand and advance the core knowledge in the field" (p.2). Consortium Internet based approaches, such as the technology management program, may face an especially difficult task in developing such a core. Although connected by the latest advancements in communication technology, scattered faculty who work at the seven different institutions in the consortium, for example, each possess their own unique sense of the field and are rarely able to confer together for long periods of time about the nature of their work. Consequently, far-flung faculty assumed that when they taught their students they were "on the same page" as instructors at the other consortium schools.

The problems created by a lack of an agreed upon base of knowledge in the consortium program initially cropped up in the manufacturing systems specialty area. Candidates in all five areas typically have a program

committee of three professors, one from the flagship university, which grants the actual degree, and two from other consortium member schools. As noted, much of the course work is done through web-site classes. After course work has been completed, a candidate's committee prepares questions for the preliminary examination. The examination usually includes questions over core class topics, research, and inquiries concerning the candidate's specialty area. In the process of giving the preliminary examination, consortium leaders in manufacturing technology discovered that some of their initial candidates did not feel they had been prepared to discuss the basic ideas and concepts in the field, ideas that might be thought of as representing a general core base of knowledge. Many professors in this specialty area were also concerned with the lack of citings on preliminary examinations of what they viewed as essential research and concepts in the field. Professors at the central consortium school, in order to respond to this deficiency, decided to develop a reading list of ten books all candidates should read and discourse upon. The creation of such a list was seen as an important first step in alleviating the core knowledge problem. This paper examines how a core-reading list was developed, the results of this effort, and the implications the process may have for other consortium type programs in both technology management and industrial technology in general.

Method

To help consortium members better define what they believed their students should read and discuss for developing a basic core understanding, a three round Delphi study was conducted. Consortium faculty from manufacturing systems were instructed to submit a list of books they believed to be essential for covering the basic ideas in their area. Altogether, fifteen professors from six out of seven universities in the consortium submitted ninety-three books. Once this list was developed, a second refining round occurred in which consortium faculty were instructed to resubmit a list. This time they could only resubmit up to five books from the first round list as most essential and were further required to submit a rationale for their choices. Interestingly, the latter instruction brought forth a lively and important dialogue among the dispersed faculty regarding what kinds of basic ideas students in the program should be examining. From this second round, twelve books emerged. A third step further refined the list. Faculty were asked to rate the second round list on a Likert type scale. In this step, participants were able to read the rationales from round two. From the third round, a final list of ten books was chosen as representing the most important ideas in the area of manufacturing systems (Table 1).

Discussion

Perhaps the most significant aspect of this consortium faculty's efforts to develop a reading list, which contained the most important ideas of the field, concerns the ten books ultimately chosen and, more specifically, what these books say about the discipline. Moody and Morley (1999), *The Technology Machine: How Manufacturing Will Work in the Year 2020*, describes the successful future worker in technology as a kind of "cross trainer" who uses a variety of techniques and who knows enough about multiple areas of the business to span back and forth between what used to be fixed interdepartmental barriers. Relying on case studies of such companies as Motorola, Honda, GM, Silicon Graphics, Solectron, Intel, Modicon, Flavors,

Table 1. Alphabetical Ordering of the Ten Selected Works.

Title	Author
Agile Manufacturing: The 21st Century Competitive Strategy	Gunasekaran, A.
Handbook of Environmentally Conscious Manufacturing	Madu, P.
Manufacturing at Warp Speed: Optimizing Supply Chain Financial Performance	Schragenheim, E.
Manufacturing, Teams, and Improvement: The Human Art of Manufacturing.	Quirk, M.
My Years with General Motors	Sloan, A., P.
The Goal	Goldratt, M. & Cox J.
The Machine that Changed the World	Womack, J., Jones, D. & Roos, D.
The Technology Machine: How Manufacturing Will Work in the Year 2020.	Moody, P., Morley R.
Toyota Production System	Ohno, T.
World Class Manufacturing: The Next Decade.	Schonberger, R.

NeXT, Japanese Railway, and Andover Controls, and their own extensive experiences with technological advances that have changed industry, Moody and Morley supply uncomplicated instructions for future progress and detail their keen vision of future systems, leaders, and workers. Faculty who selected this work also deemed it important that Moody and Morley had addressed what the two authors believe to be the three bad business habits at the root of manufacturing problems today. These destructive practices are shortsightedness, restrictive structures, and unbalanced improvement fads. The book then examines how to overcome these common and costly mistakes. Selectors also thought it critical that this book described and discussed four predictors of the types of breakthrough technologies that will come to dominate the world of the future. In that world, Moody and Morley argue that customers and suppliers will be linked by real-time/online systems, and that business will be driven by customer-designed, point-of-consumption product replication. More than one selector argued that *The Technology Machine* should be required reading not only for graduate students, but also for managers in every area of business and industry.

The Machine That Changed the World was another futuristic treatment chosen by the consortium faculty in the Delphi study. The book is based upon MIT's five year, fourteen country study of the worldwide auto industry and contrasts the increasingly obsolete mass production process of the American auto industry with Japanese auto companies' lean production model. Describing the Japanese technique as bringing together the activities of everyone from top management to line workers to the middle suppliers into a tightly integrated whole, the process, according to its authors, Womack, Jones, and Roos, (1990) "lean production is lean because it uses less of everything compared with mass production …results in many fewer defects, and produces a greater and ever growing variety of products" (p. 13). One selector pointed out how the lean production technique has changed our most fundamental ideas about manufacturing, seemingly making the American innovation of mass production obsolete. For that reason consortium faculty chose this work as a fundamental source of information for students in the consortium program. Another Japanese work selected by consortium members was *Toyota Production System*. This book explains the innovative production tactic of *just-in-time* manufacturing and demonstrates how a successful manufacturing system will change rather than stay with any particular static method even if it seems temporarily successful. Ohno (1988) states, "just-in-time means that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed. A company establishing this flow throughout can approach zero inventory" (p. 4). The book covers, for the first time, the details of how this proven process works and shows how it can be applied to any manufacturing operation. *World Class Manufacturing: The Next Decade*, another clear choice from the study, also strongly advocates a Toyota type emphasis upon change, rather than depending on status quo practices. Attacking the traditional judgment of a company's worth by sales and profit, the author, interprets manufacturing effectiveness in terms of competence, capability, and customer-focused, employee-driven, data-based performance (Schonberger, 1996). The old method, according to Schonberger, was to view improving manufacturing in terms of trade-offs. Plant managers or their corporate administrators picked one set of high-priority targets one year (for example, defect rates and warranty costs) and another seemingly conflicting set of targets to work on the next year (perhaps overhead costs and customer service rates). The high priorities of concern were thought to be where problems seemed most severe (Schonberger, 1996). *World Class Manufacturing: The Next Decade* contains a narrative of 16 management principles and an explanation of how to evaluate an industry with the employment of these principles as the scoring rubric. Indeed, the book clearly suggests that the process be understood in a holistic rather than a departmental manner.

Agile Manufacturing: The 21st Century Competitive Strategy examines the agile manufacturing technique. The process is understood as the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets. Additionally, the approach is driven by customer-designed products and services. Critical to the success of this idea is the acceptance of several new technology concepts such as the standard for the exchange of products, concurrent engineering, virtual manufacturing, and component-based hierarchical shop floor control systems, among others. One of the key elements akin to "agile" the author frequently expounds upon is proactivity. Gunasekaran (2001) states, "The turbulent environment of the future will require that all functions within the company adapt a proactive stance" (p. 21). Like other notions already discussed, the agile approach stresses holism as well as a readiness to change.

Manufacturing At Warp Speed examines the problems of manufacturing cost. The book includes a CD-ROM, which sets up a virtual company upon which the principles in the text can be tested. Like other more recent studies in the field, which take a holistic view, this book emphasizes that a truly effective, highly competitive manufacturing company integrates its manufacturing, marketing, sales, purchasing, and financial functions into a well-coordinated whole. Consortium faculty who chose this work noted that the book is so easy to read that even the novice can understand it. This body of work could potentially be adopted as a supplemental text for a production management class. Included are chapters covering a range of topics from the Theory of Constraints (TOC) through the Simplified Drum – Buffer – Rope (S-DBR). The author relates

the importance of the Theory of Constraints with the common anecdote of the weakest link in a chain. Schragenheim (2001) states, "an interesting phenomenon about chains is that strengthening any link except the weakest one does nothing to improve the strength of the chain" (p.17). Some selectors therefore noted that students should always be instructed to bring a critical eye when examining each of these works.

One interesting selection from the Delphi study was a novel, *The Goal: A Process of Ongoing Improvement*. The story, which can be purchased in book, audiocassette, or compact disk form, introduces the reader or listener to a drama involving Alex (the main character) searching for ways to rescue his manufacturing company from financial disaster. Given just three months to improve his plant's situation before the corporation closes the plant, Alex meets up with one of his former professors turned consultant (Jonah) for advice. Jonah's explanation of three key measurement constructs; throughput, inventory, and operational expense, is enough reason to purchase the book (Goldratt & Cox, 1992). The selectors found it a gripping, fast-paced business novel about overcoming the barriers to making money.

On a more humanistic level, the faculty also named *Manufacturing, Teams, and Improvement: The Human Art of Manufacturing* and *Handbook of Environmentally Conscious Manufacturing*. One selector of the former choice noted how the organizational buzzword in American manufacturing for the past ten years has been empowerment. Supposedly production people are now more empowered to make decisions about their work. Unfortunately, as the selector pointed out, in reality, empowerment still has a limited effect in most organizations. This book, however, offers a "real-world' examination of how workers and management, as a team, can improve both the work environment and production. Selectors were especially pleased that the book offered actual case studies to support their claims. Quick (1999) states; "manufacturing teams create the opportunity to mix complementary technical skills to improve the complex production process" (p.51). Moreover, the book covers manufacturing improvement programs and the latest studies regarding manufacturing teams.

Madu's work on manufacturing and the environment tackles the tough issues facing manufacturing in an ever-increasing environmentally sensitive world. Madu's book, *Handbook of Environmentally Conscious Manufacturing*, covers all the major topics in Environmentally Conscious Manufacturing (ECM). There are specific chapters that deal with sustainable manufacturing, recycling, eco-labeling, life cycle assessment, and the ISO 14000 series of standards, as well as the decision-making aspects of ECM (Madu, 2001). Decision-oriented topics on supply chain, decision models, quality initiative, environmental costing and decision support systems are also explored. The influence of ECM on the marketing imperative is also covered. One selector felt the *Handbook* was the most comprehensive treatment of ECM available to date, representing the definitive, state-of-the-art reference for ECM and its applications to today's manufacturing firms.

Perhaps the most interesting selection from the study was Alfred P. Sloan's classic *My Years With General Motors*. While the American auto making innovation of mass production is clearly considered obsolete today, the choosing of this work indicates that a historical understanding of important events in manufacturing may still help today's producers make wise decisions for the present and the future.

Implications

An examination of the ten books selected by the faculty of the consortium strongly suggests that, as a core feature, students in manufacturing technology need to understand the manufacturing arena in a holistic integrated fashion. Grasping the tasks of production as a system process rather than a mechanical/departmental process is essential. Consequently, in successful manufacturing of the future, as well as today, teamwork is more important than turf. Further, competitive production must include a mindset of flexibility. These ten books clearly demonstrate that the ability to change, in some cases radically, is a notion that should be taught and learned in a manufacturing technology graduate program. It would be enlightening if this particular process used by the consortium to identify basic core notions in the field of manufacturing technology were duplicated at other schools, which have programs similar to the consortium group. This would hopefully lead to even greater dialogue regarding the nature of the field and, consequently, add even more understanding regarding what should be the basic tasks of such programs.

Boyer (1990) has argued that successful teaching can only occur when teachers understand their subject matter and are "intellectually engaged " in their field (p. 23). The process used by the consortium to begin to identify a core understanding of manufacturing technology is offered to industrial technology programs in general as one important way of tackling the present nagging problem of defining core knowledge and as a way of helping professors to intellectually engage in their area. As Sinn and Olson (2001) have so pointedly noted regarding industrial technology, it is a discipline whose boundaries and content should be distinguished. The Delphi study discussed here, or some similar version of this process, could be one effective way of beginning to establish a core base of knowledge in any program. As the consortium's experiences demonstrated, the study certainly led to an increase in healthy dialogue concerning what the core features of its area actually were. The consortium's method of doing this, creating an essential book reading list, can also be employed at future dates, insuring an ongoing refinement of any constantly changing field.

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