Once synonymous with manufacturing, factory production today is only one aspect of manufacturing’s far-flung technology-driven processes and operations.
MANUFACTURING AT HARVARD BUSINESS SCHOOL

Building the State of the Art
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Since the beginning of this century, the rise and fall of America's economic fortunes — and the morale of the nation itself — have been inextricably linked to the performance of the country's manufacturing sector. Through times of war, depression, prosperity, and social change, a truism has emerged and endured: as manufacturing goes, so goes America.

Today, this truism holds as well for the other great powers — particularly Germany and Japan — that depend as much on manufacturing success for their economic well-being as does the United States. Indeed, in this international age, as manufacturing goes, so goes the industrialized world.

But on the eve of the 21st century, what exactly does “manufacturing” mean? From the debut of Henry Ford's Model-T assembly line in 1908 up to the present day, manufacturing has been generally understood as activity limited to the factory floor. But in reality, that view has, for some years, been as outmoded as the Model-T itself. Though the public is aware that many factories have “modernized,” the belief still holds: manufacturing is largely confined to what takes place within the four walls of the factory. Unfortunately, these attitudes are often shared by many in industry as well.

Such lingering misperceptions are not only erroneous but can spell the difference between outstanding performance and mere survival, according to researchers and faculty in the manufacturing area at the Harvard Business School. Manufacturing now incorporates such previously non-factory issues as customer assessment, design engineering, development, marketing, distribution, and field service, to name a few. This expanded totality is often referred to as Manufacturing with a big “M.”

A major agent of this transformation, advanced technology, has meant considerably more than the presence of computers and robots inside factories: it has defined and revolutionized every aspect of pre- and post-factory manufacturing activity as well. New technological capabilities have created heretofore unheard-of integration, uniting previously separate functions to an extent that has caused a creative flood of activities as they intermingle beyond manufacturing's traditionally narrow boundaries. Put simply, a focus on factory output represents only one battleground in a vast and far-flung competitiveness campaign.

At Harvard Business School, the Production and Operations Management (POM) area takes the broad view. Manufacturing must be seen as an enormously integrative process with a central imperative that unifies its various disciplines: constant improvement must be the norm if success is to be achieved. An indication of the breadth of the manufacturing
area today can be found in the variety of voices and specialties of those involved in teaching and researching the area at HBS.

"Success no longer means getting it right the first time and executing the same thing over and over again," says Kim B. Clark, the Harry E. Figgie, Jr., Professor of Business Administration and chairman of the Production and Operations Management (POM) area. "You have to get better and better everyday because that's what your competition is doing. Today's best solutions will not be tomorrow's best solutions."

Those solutions, emphasizes Professor Roy D. Shapiro, an expert on logistics and a former first-year POM course head, continually must be sought across a wide array of disciplines. "This integration of disciplines," he says, "involves many functions and operations. Managers today really need to be familiar with every aspect of their firm's operations. Modern technology enables them to know more, but also creates more for them to understand." Shapiro's colleague, Professor Ramchandran Jaikumar, an expert on flexible automation, points to the principal weapon in the technology revolution. "The computer," says Jaikumar, "is becoming a cognitive extension of the mind - an instrument of thought experiments. This has major implications for the way we characterize technological know-how, its development, and transfer in manufacturing as well as service operations."

Kim Clark and fellow HBS professors Robert H. Hayes and Steven C. Wheelwright are coauthors of Dynamic Manufacturing, published in
1988, a book that is both a manifesto and a call to arms for America's manufacturing future. (Indeed, the authors point out, their research reaches across national boundaries to any country or company committed to competing at the very top.)

Clark, Hayes, and Wheelwright attribute much of the decline of American manufacturing to a fixation with "big science" and breakthrough products that caused research and development to become increasingly out of touch with both product markets and the needs and opportunities of factories. A dedication to ongoing, continuous improvement in products and production processes, the authors believe, gave way to a blockbuster mentality that resulted in an overemphasis on major product innovation, marketing, and finance. This trend, coupled with increasing international competition, sent the American manufacturing sector into a tailspin from which it is only now beginning to recover. Stressing a return to sound manufacturing principles augmented by new technology, leadership, and learning throughout the organization, Dynamic Manufacturing offers a blueprint for restoring the manufacturing sector to its traditional place as a leading engine of the economy.

In short, to achieve exceptional manufacturing performance, an attitudinal change — throughout all levels and activities of the organization — is essential. As another POM faculty member, quality expert David A. Garvin, the Robert and Jane Cizik Professor of Business Administration, explains, "Defect reduction and quality control programs are insufficient if a company wants to achieve enduring excellence or world-class performance. What's required for a manufacturing company is the realization that product quality depends on all the operations involved: concept, design, production, marketing, service, and everything in between."

**Manufacturing in Academia**

In academia as in industry, observes Steven Wheelwright, the Class of 1949 Professor of Business Administration, schools of management have also had to refocus and reorganize their efforts. "As recently as the mid-1980s," says Wheelwright, who is head of the first-year POM course, "the belief was that a good manager could manage anything. Now it's much clearer that to be a manager in a manufacturing-based firm, an understanding of the evolution and application of technology is required. High-tech companies helped change that old attitude; when they got big enough to want professional managers, they looked for people with engineering and science backgrounds who understood technology. To prepare managers for the future, we must integrate technology and management. In a wide range of courses, we're trying to help students see that fundamental link."
As part of that effort, "We had to begin by defining 'technology' and 'technology management,'" says Robert Hayes, the School’s Philip Caldwell Professor of Business Administration and a moving force in POM for many years. "In the context of Production and Operations Management, a technology is essentially a conversion process: it converts materials, energy, and information into products and services. Managing technology, therefore, includes most of what operations managers do, so we had to choose which aspects of this broad subject we wanted to focus on in our teaching and research. Over the past few years we have been devoting much of our attention to the management of product and process development projects."

Hayes points out the degree to which time has changed that process. "As the pace of development picks up," he says, "and product life cycles contract, how do we manage technical activities to bring products to market faster? Our traditional approach at HBS — that of the manager as generalist — works up to a point. But beyond that, managers increasingly must be able to understand technical problem solving and project development processes, just as engineers must understand management." Adds Wheelwright, "Our area could well be called Technology
and Operations Management — that’s where we’re headed.”

To that end, Kim Clark explains that “to augment our traditional student body and faculty, we’re actively looking for faculty and students with engineering backgrounds. But whatever their backgrounds, we want MBAs at the end of their two years to understand the processes for developing and exploiting technology as well as they understand the other functions essential to managing a company. HBS is building a capability to bring together engineering and management, and over the last ten years, we’ve established a good foundation; there’s a lot going on at the School.”

An integral part of that foundation includes the research and course development taking place at Soldiers Field. In a wide variety of industries, HBS faculty are studying the role of product design and new process technology in creating superior performance in quality and flexibility in manufacturing; the impact of information technology on integration in the supply chain linking suppliers, manufacturers, and distributors; and the processes firms use to develop and implement new products and processes. From an even broader perspective, HBS researchers are assessing the nature of technological change itself, including the impact of information technology on product strategy and operations. (In fact, with the ever-widening influence of modern technology, faculty interest groups have formed around issues that once might have been confined to the backwaters of production and operations management. Two such groups at HBS are interested in areas dramatically ascendant in a technology-driven, knowledge-based era: the service sector group that examines production and operations as they pertain to the service sector and the management of information systems (MIS) group.)

The POM area has instituted considerable case development and research on process development and engineering, as well as the organization of new product development and its performance, and the role of the general manager in overseeing all of this. In addition, as part of a second-year elective, Developing and Managing Technology, students go into the field to audit development projects. An annual trip for first-year POM faculty — last year to Japan and this year to Europe — is conducted for the purpose of carrying out casework and research. A Science and Technology Interest Group and a Manufacturing Vision Project bring together academics (as well as, in the latter case, practitioners) from several different areas to discuss issues relevant to manufacturing. New short-term executive courses both showcase and help develop the area’s knowledge base and teaching experience.

The POM area continues to broaden its focus to address issues of integration, technology, and the engineering of new products and processes. But its faculty members emphasize that ongoing learning throughout the organization is also crucial for sustained improvement in
a firm's performance and for long-term manufacturing success. Human factors, researchers say, are as important as economic or technological issues, since misunderstood or poorly utilized methods and approaches are of little value. While the tools have advanced dramatically, successful manufacturing has always been defined by this imperative: efficient management of people interacting with machines, resources, and other people so as to produce optimal results. There is no reason to believe that this dictum will be any less valid for manufacturing in the next century.

**Innovation and Excellence**

The remarkable array of projects currently in evidence in the manufacturing area at HBS is part of a long tradition of innovation and excellence in the HBS manufacturing curriculum. Indeed, interest in manufacturing at HBS parallels the rise of the United States as a great industrial power and goes back to the earliest days of the Harvard Business School.

Edwin Gay, the School's first dean, believed that the preponderance of business activity — and the proper focus of HBS's teaching mission — lay in manufacturing and marketing. Gay further understood that in order to educate its students, his fledgling institution would have to take a leadership role in exploring and articulating the principles that drove these two fundamental areas. Thus, from the outset, the School's task was not only to teach but to help define: after all, in that first decade of the twentieth century, the nature of business and the modern management process itself were nascent concepts that were far from self-evident.

But there was no doubt that manufacturing was becoming an increasingly powerful force, transforming both business and society. One influential thinker that Gay turned to early on was Frederick W. Taylor, the father of "scientific management." Initially a reluctant recruit, but a man who would go on to deliver regular lectures at the School over a period of years, Taylor was noted for his theories on the nature of individual work and the functioning of the workplace. Though later criticized for ignoring the human relations dimension of the workplace, Taylor's time-and-motion studies offered solid evidence that sound organization and management were instrumental in creating productive manufacturing.

While Gay understood that there was more to management than Taylorism, scientific management's controversial precepts helped the School's founding fathers weigh their own views of what HBS should teach and investigate. Indeed, Taylorism provided much of the academic content for the School's initial course in manufacturing, Industrial Organization. First offered in 1908, the course, though an elective, was
Time and motion on the Ford assembly line in 1908.
"Scientific management" also debuted at HBS in 1908, the School's inaugural year.

taken by a majority of students and was immediately popular: it dealt with specific factory problems and provided a framework for those managers-in-training who realized the growing complexity of manufacturing operations. The course (renamed Manufacturing in 1914) took its place among such other curriculum offerings as Banking, Railroad Organization and Finance, and Economic Resources of the United States.

In 1920, the course, now called Industrial Management, became a required first-year course and was soon known simply as Production. Production devoted much of the first half of the year to a variety of employer-employee issues. The second half delved "much farther into matters of control, routing, and the scheduling, accumulation, and distribution of costs," according to the 1922 course catalog.

The twenties saw the emergence of notable new professors and courses in the area. Franklin Folts, who was to head the faculty Production group from 1928 to 1960, took a leadership role (along with Professor Edwin Robbins) in introducing the case method to the teaching of Industrial Management. Folts helped guide the area through the 1930s, when U.S. manufacturing was in obvious decline, in part by shifting its functional emphasis to a broader view of the factory as one element of a larger world of corporate issues and managerial concerns.

In 1926, a new course, Manufacturing Industries, marked the debut of General Georges F. Doriot in an HBS career that eventually spanned forty years. Seven thousand MBA students took Doriot's course (later to be merged with and become the substance of Business Policy) and many would later recall the Doriot class as the most influential of their HBS careers.

In the 1930s, field studies at selected plants became an important part of the second-year manufacturing curriculum. While Production's emphasis remained on nuts and bolts, Doriot's new second-year elective, Manufacturing, incorporated some of the more philosophical and ana-
lytical policy considerations that were becoming part of the area. By viewing a company's operations and performance from the standpoint of interested outsiders such as bankers or consultants, Doriot's course endeavored to show, the School explained, "the basic differences between analyzing, advising, and actual executive work." Its final report had students trying to project twenty years into the future the effect of a contemporary problem, product, or technology they had exhaustively researched.

**Into the Modern Era**

With the onset of World War II, a course called Production Organization and Engineering (POE) was introduced into the MBA curriculum. POE taught basic workplace skills such as blueprint reading and time studies and included the proper use of machine tools, spot and arc welding, calipers, micrometers, fixed gauges, decimal stop watches, and instructional films that explained various production processes. After the U.S. entered the war, the School became a retraining ground to help peacetime managers oversee the country's wartime production needs. The program's purpose was to retool mature executives who had little, if any, relevant experience and to prepare them for management positions in industries producing war matériel. (The experience of educating executives in mid-career was so successful that it became the inspiration for the School's Advanced Management Program and other programs and courses in executive education.)

Perhaps because of this wartime emphasis, with the resumption of civilian instruction at the School after the war, the pendulum seems to have swung back to the shop-floor focus of an earlier time. Production was now described in the MBA course catalog as "an operating subject that deals with methods and techniques of execution and supervision to a greater extent than with policy formulation." Technological development in that pre-computer age had already become a priority — particularly in Professor John McLean's Advanced Production Problems course — though its horizons did not extend beyond the factory floor. Second-year electives, however, explored both policy and practice in greater specificity.

Amid post-war tranquility, and spurred on by war-stimulated advances in production expertise, the halcyon era of U.S. manufacturing preeminence began. From it emerged an interest in broader aspects of management, an apparent outgrowth of a confident nation's overwhelming global reach, a supremacy based on its logistical mastery of production and operations.

But storm clouds were building on the horizon. Perhaps due in part to overconfidence, a kind of lethargy had taken root in American manufacturing. Industrial plants and equipment were allowed to deteriorate and
become outdated. Product quality suffered. By the end of the 1960s, signs of trouble were evident. A perception had taken hold that manufacturing was a slow and conservative world with dirty factories and no fast track to the top. Careers in manufacturing lost much of their glamour as opportunities for rapid advancement appeared in other industries. At HBS, this was reflected in an increasing decline in MBA interest in manufacturing even as overseas competition began severely challenging U.S. industries.

As a result, considerable soul-searching and lively debate were going on within POM. Faced with declining industry performance and lack of student interest, POM faculty were uncertain about the area's proper role and definition. Since the mid-1960s, Professor Wickham Skinner, POM chairman, had been insisting that prevailing assumptions in the U.S. about manufacturing and competitiveness were no longer valid. Under his guidance and that of Professors Paul Marshall, Earl Sasser, and others, the POM area regrouped, convinced that it had a leadership role to play. It saw its responsibility as getting to the heart of what made POM important and determining how to convey that in a relevant, exciting, and challenging way to students. A particular imperative was to produce a fresh round of cases that, as Skinner put it, would make "clear connections between the success of POM in the firm and overall corporate results."

This response to manufacturing's needs was unique to HBS. By the mid-1970s, most other business schools had evolved their operations groups to rarefied levels of statistics and mathematics, rather than addressing the practical problems facing industry managers. A number of schools were even dropping POM altogether. Academic rigor had been satisfied, but practical preparation of students for general management positions was sometimes missing the mark.

But Skinner, who was, in effect, an early proponent of what was to become the "Big M" movement, was convinced that HBS should maintain its "unique heritage of treating POM as a vital area and skill of management." He insisted that manufacturing involved much more than what went on in the factory; the narrow, static, non-integrative focus of U.S. manufacturers was at the root of their growing problems. The management of service operations should receive increased attention, Skinner thought, as well as emphasis on applying evolving technologies to related activities and operations outside the factory.

These events were, of course, in good part occasioned by the emergence of the broader international and technologically driven business environment that has become the familiar norm today. The new focus drew an enthusiastic and sustained response from students. Thus, as had happened in the past, the POM area at HBS — sometimes, it seemed, alone among schools of management — was redefining production and operations management and taking it into the future.
By the 1980s, POM's view of American decline as largely due to a misreading of the new global economic order and the requirements of manufacturing competitiveness was widely accepted. The historic 1980 Harvard Business Review article, "Managing Our Way to Economic Decline," by Robert Hayes and the late Professor William Abernathy, that so galvanized attention to America's decline, owed much to Skinner and his POM colleagues' earlier assessment and persistence. Significantly, it was through the efforts of Skinner and others that Human Resources Management made its debut in 1981 as the first new required MBA course in twenty years. Manufacturing strategy, another Skinner concept, was developed at the School and has become a major intellectual contribution to the world of manufacturing and business.

The current effort to develop a broad understanding of engineering, its problem-solving processes, and its management as a function, is a natural step for the POM group. It builds on a solid foundation of manufacturing and technology and provides a focal point — new product and new process projects — for addressing important issues of functional integration.

By sounding alarms and offering new solutions, HBS faculty, through their research, teaching, books, colloquia, articles (particularly in the Harvard Business Review), and students they have sent forth into industry, have had an enormous impact on the way manufacturing is currently viewed and managed.

In sum, the manufacturing area at HBS today is continuing a tradition of academic leadership that dates back to F. W. Taylor and Georges Doriot. In the 1990s, manufacturing success will increasingly demand competitive, ever-improving excellence in a dynamic manufacturing environment. In the pages that follow are descriptions of some of the HBS faculty research that is helping to define a new world order of technology innovation and manufacturing success.