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CROSS-FUNCTIONAL MANAGEMENT OF TECHNOLOGY

CASES AND READINGS

Cross-Functional Management of Technology

Cases and Readings

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To John Thomas Walter, Jr., in whose honor the Thomas Walter Center for Technology Management was established at Auburn University.

P R E F A C E

Courses in management of technology (MOT) are now routinely offered in most business schools, and M.B.A. programs offering MOT as a concentration, track, or primary emphasis are growing in number each day. According to the lead article in *MBA Newsletter*, more and more M.B.A. programs are producing "techno-M.B.A.s" from universities with the two colleges of engineering and business.[1] According to this article, out of the total of 75,000 M.B.A.s graduated each year, 3,750 (5 percent) are expected to be techno-M.B.A.s; this number is expected to grow each year.

The engineering curriculum is strong in its narrow specialization, but it lacks the knowledge and skill development that are needed by engineers to function effectively within organizations. We are preparing engineers to be a excellent science-based engineers but weak business people and managers. Clearly, not all engineers will become managers and business people. But how can we lay the foundation for those who will be active on the business side to be effective business people or managers as well as effective engineers?

What about the business curriculum? Many mistakes of our manufacturing firms can be traced to an inadequate understanding of technology, product design, and manufacturing. At least partly because of the recognition given to these mistakes, many business schools are considering changes in their curriculum for both undergraduate and graduate education. The key concept in most curriculum changes is integration across disciplines within the business school. The next step should be to consider integrating the issues from engineering that are pertinent to the effective management of manufacturing firms. How can this be done?

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1 "Programs in Technology Management Grow as More Companies Seek Techno-MBA's," *MBA Newsletter,* August 1994. *MBA Newsletter* is a publication of Kwartler Communications, Inc., Floral Park, NY.

Technology management lies at the interface between engineering and business. It is probably the best body of knowledge that is available today to help integrate engineering and business education. One can see it happening already—many business schools have introduced courses and concentration in technology management in the last five years.

We are grateful to the business and engineering faculty, who were aware of the existence of the National Consortium for Technology in Business (NCTB) cases and encouraged us to publish them in the form of a book. We invite all users of the cases to give us feedback on improving these cases and the selection of readings.

Every case included in this book was developed by a cross-functional team of at least one faculty member from the college of business and another from the college of engineering. The cases have been tested by use in both engineering and business schools by the authors. In some instances, the cases were used in combined classes of business and engineering students, and in other instances, the cases were offered in separate classes to students from the two colleges. Either way, the content was found suitable for students in both colleges. Experience indicates that students from both colleges learn more when the cases are discussed in a classroom where both business and engineering students are present.

The chapter format of the text should provide teachers with a structure that will speed their ability to put together a course curriculum on the subject matter. In addition, we would strongly urge all teachers and students to view the readings that accompany the cases in particular chapters as being relevant to the cases in the various other chapters.

M. Dayne Aldridge
Paul M. Swamidass

A C K N O W L E D G M E N T S

This book is the compilation of the work and cooperation of many people. The editors have contributed in complementary ways to the program that sponsored the development of the cases presented here. One of us (Aldridge) developed the competitive Curriculum Development Program for Schools of Business and Engineering; the other (Swamidass) provided the vision and leadership for the publication of this text. But we both are indebted to numerous individuals and organizations that made this work possible.

A gift from the Perot Foundation made it possible for us to experiment in curriculum development through the joint efforts of business and engineering faculty under the auspices of the National Consortium for Technology in Business (NCTB). This casebook is a result of one of the projects made possible by the gift.

The Curriculum Development Program for Schools of Business and Engineering touched dozens of faculty all over the United States as case writers, proposal evaluators, case workshop attendees, and users of cases developed through the efforts of the NCTB. Further, hundreds of students in more than 10 universities were involved when their teachers/case developers tested the cases for instructional purposes. Nearly 20 businesses and organizations worked to enable 26 faculty to experience real-life business and engineering problems that they could take to their classrooms as well as describe them in their cases for the use of other faculty.

We want to express our thanks to the faculty from business and engineering colleges across the United States who participated in our competitive grant program to develop cases for use in business and engineering colleges. Out of a total of 59 proposals from 56 universities we received in the summer of 1992, 10 teams of business and engineering faculty were selected to develop 26 cases. We are grateful to the panel of experts who helped us in selecting the 10 teams for awarding grants. The experts were Carl Adams, Professor of Information and Decision Sciences, University of Minnesota; Denny Avers, formerly of IBM

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1. E. B. Roberts, "Managing Invention and Innovation," *Research-Technology Management* 31, no. 1 (January/February 1988).
2. S. C. Wheelwright and K. B. Clark, "Competing through Development Capability in a Manufacturing-Based Organization," *Business Horizons*, July/August 1992.
3. J. R. Dixon and M. R. Duffey, "The Neglect of Engineering Design," *California Management Review* 32, no. 2 (Winter 1990).
4. M. Maccoby, "Teams Need Open Leaders," *Research-Technology Management,* January/February 1995.
5. R. A. Lutz, "Implementing Technological Change with Cross-Functional Teams," *Research-Technology Management,* March/April 1994.
6. J. B. Quinn, "The Intelligent Enterprise: A New Paradigm," *Academy of Management Executive* 6, no. 4 (1992).
7. D. J. Teece, "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy," *Research Policy* 15 (1986).
8. M. M. Menke, "Improving R&D Decisions and Execution," *Research-Technology Management,* September/October 1994.
9. P. M. Swamidass, "Making Sense out of Manufacturing Innovations," *Design Management Journal*, Spring 1995.
10. "The Celling Out of America," *The Economist*, December 17, 1994.
11. M. J. Tyre, "Managing Innovation on the Factory Floor," *Technology Review*, October 1991.
12. L. U. Tatikonda and M. V. Tatikonda, "Tools for Cost-Effective Product Design and Development," *Production and Inventory Management Journal* 35, no. 2 (Second Quarter, 1994).

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C O N T E N T S

Cross-Functional Management of Technology

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The designer sat at his drafting board;
A wealth of knowledge in his head was stored,
Like, "What can be done on a radial drill,
Or a turret lathe or a vertical mill?"
But above all things, a knack he had
Of driving gentle machinists mad.

So he mused as he thoughtfully scratched his bean,
"Just how can I make this thing hard to machine?"
If he made this body perfectly straight,
The job had ought to come out first rate.
But 'twould be so easy to turn and bore
That it would never make a machinist sore.

So he'll put a compound taper there
And a couple of angles to make 'em swear,
And brass would work for these little gears,
But it's too damned easy to work, he fears,
So just to make the machinist squeal
He'll make him mill it from tungsten steel.

He'll put those holes that hold the cap
Down underneath where they can't be tapped;
Now if they can make this, it'll be just luck,
'Cause it can't be planed and can't be ground,
So he feels his design is unusually sound,
And he shouted in glee, "Success at last!
This damned thing can't even be cast."

Kenneth Lane*
General Electric

*Poem quoted by J. P. Haher, "A Case Study in the Relationship between Design Engineering and Product Engineering," *Proceedings of the 5th Annual Meeting of the Industrial Engineering Institute,* UCLA, 1953.

One can trace three major mileposts in the evolution of management during the last 100 years. First, during the second half of the last century, Fredrick Winslow Taylor originated a principle of management, dubbed Taylorism, which is founded on managers' acquiring scientific knowledge concerning the structure and content of work in order to direct workers to perform optimally through incentives and punishments. Several decades later, in the 20s, Elton Mayo, through his experiments at the Hawthorne, Illinois, factory of Western Electric, found what is known as the Hawthorne effect, which is the increase of worker productivity when personal attention is given to workers. Mayo observed that upon receiving personal attention, group members develop a sense of participation. Mayo's work is considered to have given rise to the human relations approach to management, whose influence prevails to this day. The last milepost is the present-day emergence of team-based management, particularly the rise of cross-functional teams to deal effectively with the new competitive environment of shorter-product life cycles, time-based competition, intensified global competition, and the fast-changing nature of product and process technologies.

Notably, the first two significant mileposts in management arose from a motivation to increase the productivity of individual workers. In contrast, the rise of cross-functional teams is motivated by a multitude of goals in which the goal to increase the productivity of direct workers assumes a lesser role. Firms move into cross-functional team-based management to compete effectively in product markets where product life cycles are very short, where product and process technologies become obsolete soon, and where extremely low cost and near-perfect quality are mandated by the market.

Some view the last milepost as an unparalleled paradigm shift in management. In this environment, the individual worker's productivity is no longer the central focus. Here, timeliness of getting the products to market, near-perfect quality, and lowest possible total cost (life-cycle cost) are all equally important. In this environment, the effectiveness of management, technical personnel, and other white collar employees is presumed to enhance the productivity of individual workers. Any organization that deals with products or processes involving technologies that are intensive and dynamic cannot do well in today's competitive environment without the use of cross-functional teams. This text presents several cases and readings on the circumstances that need cross-functional teams and on the effective use of these teams.

What Is Management of Technology?

Management of technology (MOT) became a topic of intense discussion during the 1980s in response to the perceived decline of international competitiveness of U.S. industries. The National Research Council (NRC) report "Management of Technology: The Hidden Competitive Advantage" probably did more than any other publication to focus and accelerate this discussion. The NRC report described MOT as "an industrial activity and an emerging field of education and research." The report provided what has become the most widely quoted definition of MOT: "Management of technology links engineering, science, and management disciplines to plan, develop, and implement *technological* capabilities to shape and accomplish the strategic and operational objectives of an organization."

Someone has said that people can understand the terms *management of employees, management of finances,* and so on, but they do not understand the term *management of technology.* The following definition, when taken together with other definitions, may help readers grasp the meaning of MOT.

> Narrowly, technology is any means of accomplishing a task; shoveling dirt is a technology. By incorporating engineering and technology management, we restrict our domain to technologies embodied in products or processes that require some engineering/scientific knowhow to comprehend. . . . MOT principally addresses three levels of analyses: who carries out technical exploration, how it is carried out, and what its impact is on the organization and its environment. (Anderson, 1993, p. 17)

MOT definition is difficult because it draws from several disciplines. "As a cross-disciplinary field, the scholarly literature on management of technology (MOT) has been 'borrowed' from related scientific fields of study such as sociology, economics, psychology, mathematics, political science, statistics, management science, systems theory, and anthropology" (Badawy and Badawy, 1993, p. 1). Some readers may add engineering, sciences, operations management, and information systems to the list of disciplines contributing to MOT. Our understanding of MOT may be enhanced if we consider how MOT is practiced; this is addressed in the following paragraphs.

How Is MOT Practiced?

A study of chief technology officers (CTOs) and their responsibilities offers an insight into what is involved in managing technology. Adler and Ferdows (1990, pp. 58–59) found that CTOs engaged in:

1. Coordination among business units' technological efforts. This included (*a*) avoiding duplication of effort in different business units, (*b*) assisting the transfer of technology from one unit to the other, (*c*) commercializing technology, (*d*) ensuring synergy between product and process technologies, and (*e*) coordinating between the business units and corporate research, across business units, and across functional areas.
2. Providing a voice for technology in the top management team. This involved (*a*) pushing for a long-term view of technology, (*b*) nurturing infant technology projects, and (*c*) providing expertise on technological questions and issues.

3. Supervision of new technology development.
4. The assessment of technological aspects of major strategic initiatives such as (*a*) new acquisitions, (*b*) joint ventures, (*c*) strategic alliances, and (*d*) long-term trends in technology.
5. The management of the external technology environment. This is a varied task including (*a*) dealings with universities and research organizations, (*b*) relations with regulatory organizations, (*c*) providing guidelines for funded research, (*d*) collecting signals about important technical developments outside the firm, (*e*) ensuring that products and processes complied with relevant regulations, (*f*) identifying regulatory trends and regulatory constraints, and (*g*) influencing the regulatory process.

Adler and Ferdows found that the management of technology within a firm may be associated with a mixture of diverse functions such as R&D, engineering, manufacturing process technology, information systems, and operations support.

Emerging Challenges in the Management of Technology

The management of technology in the 1990s in high-tech industries is faced with new and more demanding challenges. For example:

1. The inverse relationship between technological capability and price in some industries (e.g., the digital products industry). This fact is revolutionary and contradicts an established principle of commerce true in most other industries. Since the invention of transistor chips and micro chips, product capability or power goes up but product price comes down. "The cost of raw technology is plummeting toward zero" (Gross, Coy, and Port, 1995).
2. Product life cycles are very short and difficult to pace. Long-term plans (5 to 10 years) are becoming less and less meaningful in some fast-moving industries.
3. Start-up marketing costs in some products can be very high. For example, first-generation products are given away to lure long-term customers (e.g., the computer program Simply Money—1 million free copies were shipped by Computer Associates International Inc. as a tactic to enter the market).
4. Changing technology can disrupt successful product strategies. Unsuccessful product strategies in the wake of changing technology were evident in such firms as IBM, DEC, and Wang, to mention a few.
5. Product pricing is difficult when, according to a Japanese executive, "quality is perfect and nothing breaks."

When quality and price among competitors' products are comparable, competition on the basis of time emerges to the forefront. The ensuing time-based competition is enhanced by a number of things, including product and process technologies, and cross-functional management of technology.

Time-Based Competition and Technology Management

In the last 10 years or so, as time-based competition has become more prevalent, a major concern for business is the need to cut lead time continuously. One aspect of time-based competition is the reduction in the time it takes to bring a new product to market. In some industries, such as the electronics and computer-related industries, "a new product that is brought to a rapidly changing market on time but 50% over budget cuts profits only by 4% over the first five years. Yet, coming out six months late but within the development budget it will earn 33% less profit" (Gerwin and Guild, 1994, p. 679). Thus, there is a heavy price to pay for any time-to-market delay. A number of efforts are under way in organizations to cut the time-to-market cycle. Process reengineering is one popular tool to make gains in reducing lead time.

Reducing the lead time has significant impact on the management of technology. Particularly, it requires good cross-functional working within the firm. The effect of continuously reducing lead time can be felt in the following areas of MOT:

1. New product introduction.
2. R&D management.
3. New process technology implementation.
4. Product–process interaction.
5. Cross-functional teamwork and other forms of organizational adaptations.
6. The technology commercialization process.

The impact of lead-time reduction on selected areas in this list is elaborated below. In the following discussions, some of the issues relevant to managers and engineers are highlighted.

New Product Introduction

With shrinking product life cycles (PLC) and time-based competition, the importance of new product introduction cannot be overstated. New product introduction involves numerous "problem solving cycles" (Clark and Fujimoto, 1989) that involve "design-build-test" cycles until the successful product is ready for a launch. Lead-time reduction amounts to cycle-time reduction,