Management Of Technology: Future Directions and Needs for the New Century

Report of the Workshop on Management of Technology and the Paradigm Shift in Education in Response to the Technology Revolution

MANAGEMENT OF TECHNOLOGY:
FUTURE DIRECTIONS AND NEEDS FOR THE NEW CENTURY

**Report of the Workshop on
Management of Technology and the
Paradigm Shift in Education in
Response to the Technology Revolution**

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ABSTRACT

The world is witnessing a very rapid pace of change in technology and business environments. These intense and dramatic changes are projected to continue into the next century. As a result of these technological advancements, rapid communication and greater diffusion of information technologies will continue to grow. This increase in ability to communicate will significantly contribute to wealth creation and force a change in models of economic growth in the knowledge era of the twenty-first century.

It is therefore important to recognize the drivers for industrial, technological, business and educational changes. It is also necessary to muster the ability to deal with such drivers through improving the capabilities of contemporary industry and educational institutions, particularly with regard to the integration of technology and business strategy. The field advocating this integration has been called the "Management of Technology" (MOT).

A workshop was held in 1998 at the National Science Foundation (NSF) Headquarters in Arlington, Virginia to discuss pertinent issues in the Management of Technology. Participants at the workshop identified many issues as the primary drivers of change in the 21st century, classified under seven main topics. These seven drivers were identified as the priority focus areas deserving attention by practitioners and researchers in the field:

1) Technology
2) Changes in Business Environment
3) Communication, Integration and Collaboration
4) Strategic Directions of Industry
5) Changes in Organizational Structure
6) Financial Sector Structure
7) Education and Training

Participants discussed the needs for educational improvements to meet the demands of modern technology-based corporations. It is accepted that educational institutions can benefit from definition, better structure and more unified framework for the Management of Technology field in order to effectively respond to the demands of a diverse array of stakeholders and customers. The benefactors of these improvements include students, their future employers, top managers, professional groups, technical and managerial employees and other customers. A framework for MOT education is proposed in this report.

It is necessary to create an information dissemination campaign in the field of Management of Technology in order to communicate, to all, the value of this field in creating sustainable wealth and prosperity. The need for development of a stimulating educational process in the area of MOT is a growing national necessity. The development of a MOT educated work force is imperative to the future growth of industrial and service organizations. To be effective the academic programs should be experience based and not rely solely on theoretical models. These programs should rely on the input of industry itself in the development of practice-oriented education.

In order to entice industry and education to become involved in these changes, a strong public relation effort needs to be mounted. In the meantime universities should modify institutional rewards, or offer other attractive benefits, in exchange for applied work within industry in order to entice tenured professionals to enter into this arena of study. Additional resource allocation for further MOT research is also needed. Both government and industry should sponsor innovative MOT programs for human resource development within educational institutions and industry.

I. GENERAL TRENDS IN TECHNOLOGY, MANAGEMENT AND EDUCATION

Participants at the 1998 National Science Foundation/University of Miami (NSF/UM) workshop identified many issues as the primary drivers of change in the 21st century. These drivers were classified under seven main topics:
1) Technology
2) Changes in Business Environment
3) Communication, Integration and Collaboration
4) Strategic Directions of Industry
5) Changes in Organizational Structure
6) Financial Sector Structure
7) Education and Training

The intensity of changes in technology are projected to continue into the next century. The rapid communication and diffusion capabilities of information will grow, resulting from technological advancements. The Internet, for example, is an avenue for the provision of extensive amounts of raw information, accessible by many people. Through it, interactions can be two-way or multi-way and will foster collaboration in departments within organizations as well as between organizations well into the future through enhanced communication.

In addition to information technologies, another technical area where major and rapid change will continue, is molecular biology. Industries such as healthcare, agriculture and genetic-based corporations are likely to be privy to great changes in technology within genetic engineering, biotechnology and connecting to nanotechnology.

Also continuing will be the enhancement of performance of technology as a whole by the advancement of technology and technology sharing between various disciplines and concentrations. Fusion of technologies will continue though the develop-

ment of multiple products that integrate material, mechanical, electronic and manufacturing technologies, leading to even more complex products. This, in turn, will require engineers and managers to be wired together and adaptive to a multi-disciplinary world. Thus the increased technological complexity drives the environment towards multi-disciplinary cooperation, cross-disciplinary training and cross-cultural contexts. The cost and complexity of technology, as well as the drive to maintain a competitive edge also prompts increased pressure on corporations to respond by creating new technology. Pressures continue to lead to collaboration among companies who have been traditional rivals.

Changes in business environments are occurring, being partially driven by the new information technologies. The imperative of the new information technologies continues to drive a kind of technological imperialism in different areas of business disciplines. Finance, marketing, innovation, engineering and public relations all use technology and innovation as the common core to compete. Innovation competition among all business processes will be a dominant factor in determining business success.

This includes the emergence of multiple stakeholders and leads to the need for a manager who is able to deal with demands of a diverse array of issues as well as diverse stakeholders. In addition, the business environment must continue to ensure that the systems responsible for the generation of knowledge are effective. Corporate research laboratories established in the early twentieth century have undergone major changes, such as the GE and Bell labs (with some observers arguing that these labs have become weaker in the generation of new knowledge than when they were 20-30 years earlier). Similarly, government and defense research laboratories have come under pressure following the cold war era. Knowledge generation is always a key entry point for effectively managing technology, and must be supported by innovative policy development and a resurgence of research funding in the development of new technology.

Due to the new information technologies, Intellectual Property Rights (IPR) has become a fast-changing and multifaceted area, and provide a changed legal and logistic challenge to corporations. This emphasizes need for a better structured Intellectual Property Rights agreement. Parallel to this, new and enhanced security and legal issues drive the need for a change in corporate records and information systems. The need for corporations to master communications technology is particularly important because of the quantity of corporate records stored in cyberspace.

Moreover, the context for technological change continues to be global. Global stakeholders and competition encourage more global alliances. A dynamic global marketplace creates the need to educate members of the organization in international business practices. And parallel to this is the increasing trend in industry towards greater dependence on the outsourcing of some aspects of technology to small and midsize companies. Worldwide this fosters greater collaboration, mergers and joint ventures in order for companies to compete effectively. Thus multiple parties involved in innovation create multiple ownership by competitive corporations working in the same technology.

The explosive use of the Internet, has caused a "bottom-up" revolution, where communication within companies and communication between the business and the customer has been utilized in order to foster business growth. Accordingly, collaboration, communication, and integration among departments and organizations is increasingly important as information technology continues to change. Collaboration among companies consists of increased global alliances, joint research, development and production projects. The integration of departments within the organization needs to build synergy and create a unified organization working collaboratively around an end product. Increasingly, there are more sophisticated consumers and more collaborative relationships between government and business.

As the changes in the competitive environment continue, so too the traditional issue of social justice around the world continues and changes in form. Because of the global economic environments, individual governments can not longer attempt to achieve change completely on their own. A strong role must be played by industry;

and multi-national organizations seem to be on the forefront driving globalization. This creates a more complex interaction of different sectors, forms and capital in the world.

The strategic planning process of organizations must recognize intellectual capital and tacit knowledge. This process will also help to define the cultures of the organization and those of employees and customers.

New technology continues to fuel entrepreneurial activities and lead to growth of small businesses. The proper use of these small businesses can contribute to the overall growth of technology and the economy. Not only fueling new entrepreneurial activities, rapid changes in technology have made it important to begin replacement or improvement technology immediately following the development of new products. Shorter business and technology phases are creating a greater need to closely integrate between the two.

Another consequence of information technologies is the growing trend to move away from fixed, permanent organizational structure to a more temporary and flexible structure. Organizations may be assembled to meet specific needs or special technology and disbanded as the technology changes or the need disappears. Thus organizations are increasingly changing their structure from a vertical hierarchy (the traditional model) to a more horizontal or network model. There is an additional expectation of greater integration among and within organizations, especially aided by the computer/information technology and the incorporation of Internet.

Financial opportunities which use the creation of mergers/acquisitions, particularly in organizations dealing with mature technology, continue to occur as corporations realize the benefits to combining technological expertise, economies of scale* and the elimination of organizational duplications. Another interaction of technology and finance occurs because of the continuing pace of change in complex technology. This creates a need for new techniques to assist venture capitalists in improving their justification of investment in technology.

The information technologies have had a dual impact, both in automation of hard good production and in the expansion of information services. The production of non-physical products and services continue to grow in importance. At the heart of all information technologies, knowledge continues to be the driver behind supply chain strategies, driving innovations in product, production, distribution and marketing. Yet even in this global knowledge environment, how and what a corporation designs will continue to be influenced by cultural influences. There is a new need to create public policy leading away from parochialism and ethnocentric trends. In education and training, industry has been leading the way towards change and organizational flexibility necessary for survival in the 21st century. In the educational arena, universities and schools need to adapt to constantly changing technologies. This adaptation is required in curricula and in the way of delivering education.

The linking of technology creation to the sustainability of economic, environmental and social development becomes increasingly important for education. Moreover, the potential of the changing information technologies can facilitate the delivery through the emerging channels of distance learning and electronic educational delivery methods. Universities are beginning to emerge from delivering only local education to delivering education throughout the world. Multiple degree seekers are increasing, probably resulting in the future where few managers have only a single advanced degree. The need for more technological and managerial education for all managers continues. Business leadership to run companies of the future must focus on knowledge generation and application, emphasis on innovation, integration of organizations and collaboration.

A new discipline model of education, based on knowledge infrastructure integration and cultural acceptance, is needed to prepare people for the future of global technology. Moreover, despite the importance of new modes of education, hands-on training and involvement need to be a part of any educational model.

II.   1998 UM/NSF WORKSHOP

In September of 1998, a workshop co-sponsored by the National Science Foundation (NSF) and the University of Miami was held at NSF Headquarters in Arlington, Virginia. This workshop examined the future directions in the Management of Technology (MOT) and the need for a paradigm shift in education in response to the technology revolution. As identified in several of the position papers presented by the workshop participants, there are many issues which need to be incorporated in a strong program or discipline focused on MOT in order to meet the demands of industry. The ultimate goal is to create a program that transcends the barriers of the rigid, unyielding nature of compartmentalized disciplinary programs in most Universities. The global and cultural changes within industry, as well as growing application of technology, require changes in human resources development. Additionally there is the need to concentrate on the preparation of the new work force for the 21st Century.

The shift in business practice predicted earlier in MOT workshops held in 1987 (NRC, 1987) and 1988 (Khalil and Bayrktar, 1988) seemed to already have occurred through a strong response by both industry and academics. Participants of the 1998 workshop recognized that another shift in business paradigm is being forced by a relentless change in the business environment due to the fast pace of technological growth and to the effects of globalization.

The deliberations of the participants demonstrated the strong need for enhanced collaboration between industry and education. Additionally the discussions focused on existing drivers which will be of key importance in the change in the scope and contents of MOT in the 21st century.

III.   BACKGROUND

Today there is a rapid change in the technology and business environments. Traditional measurements of the value of a business according to assessment of physical assets or based on an accounting or finance formula are inadequate in the new world economy. The inclusion of intangible assets such as intellectual properties, service based products, information technology and many of today's rapidly growing arenas are not well defined within the models upon which business and engineering schools have based their curricula.

The stock market's reaction to technology stocks and the current global financial crisis suggest that not only further research but new definitions and concepts within the field of Management of Technology (MOT) are needed. Many of the existing models in engineering and management education need to be challenged. The traditional programs in engineering and management education need to take in account the volatilities of the environment in which the technology is created and applied.

In the 1970's and 1980's the U.S. experienced an increasing global competition leading to loss of market share in several industry sectors. This became a concern to government, industry and educational interests. As a result, several initiatives were formed in order to identify the sources of decline and to formulate a response to the challenges within global competition. The National Research Council (NRC), the National Science Foundation, the American Association of Engineering Societies, the Accreditation Board for Engineering and Technology, the American Assembly of Collegiate Schools of Business, Oak Ridge Associated Universities and others were among the lead organizations in the search for explanations and solutions to declining U.S. industrial competitiveness. U.S. businesses were also searching for a foothold with which to better compete for wealth.

As a result, many stakeholders banded together in the search for a solution to these problems. In a series of workshops in the mid-1980's experts gathered together to

discuss emerging MOT concepts. One workshop was organized by the National Research Council (NRC) and another was organized in 1988 by the Public Affairs Council of the American Association of Engineering Societies. Workshop attendees identified as a priority the need for a change in the manner in which the technological environment was managed. The resulting consensus was that a significant amount of effort should be directed towards the improvement of the MOT.

Technology has a great influence on individuals, business, society and nature. Advances which occur in technology have a major influence on creating national and individual wealth and on improving people's standard of living and quality of life. The increased interaction between society and technology provides the impetus directly for the importance of concentration on the development of their relationships within the MOT field, and a need for further clarification of the role which MOT plays in all stakeholders' interests.

Participants in the debates surrounding MOT came to the realization that the decline in the U.S. corporations' marketplace competitiveness was due, largely, to emerging global competitiveness and to an inability of the people within corporations to effectively manage the dynamic changes in the business and technology environments. Important problems identified were the inability of corporations to realize the true power of technology, effectively exploit technological capabilities, and provide timely turnaround of existing and newly developed technology into commercial end product. These problems were considered to be the foremost among several managerial problems existing in many organizations during that time frame.

In a 1987 workshop report by the NRC, "MOT: The Hidden Competitive Advantage," the primary recommendation was that the knowledge and practice gap between engineering/science and business/management be bridged. The NRC report reasserted the importance of the MOT in restoring U.S. competitiveness in global markets. The NRC report indicated that there was a great need to support both education and research in the area of MOT.

The NRC report also identified a great need to pursue research in technology management and urged funding agencies such as NSF and NASA to support such research. Among the first steps in the quest for increased focus on research and education in the management of technology was the need to provide a definition to the field of technology management. The Task Force on MOT defined the MOT as "linking engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization."

Upon agreement on a definition for the MOT, the NRC report detailed several industry needs that should be addressed and incorporated within research and development of new teaching and management practices:
- How to integrate technology into the overall strategic objectives of the firm
- How to get into and out of technologies faster and more efficiently
- How to assess/evaluate technology more effectively
- How best to accomplish technology transfer
- How to reduce new product development time
- How to manage large, complex and interdisciplinary or inter-organizational projects/systems
- How to manage the organization's internal use of technology
- How to leverage the effectiveness of technical professionals
- Research and education diverted towards satisfying these needs were deemed essential for U.S. industry to regain its leadership position.

Working towards the same end goal, an NSF sponsored workshop was held at the University of Miami (UM) in 1988. It followed the first International Conference on management of technology held in Miami, Florida in February 1988. A report on the workshop, published by UM/NSF entitled "Challenges and Opportunities for Research in the Management of Technology" was released in 1988 as a result of this two-day workshop. The International Conference on MOT and the ensuing workshop focused a significant effort in clarifying the emerging MOT field. The released workshop report defined five major issues as the key priorities for research

opportunities within the MOT. These issues are:
1) Methods and tools for managing technical resources
2) Managing the interface between the organization and the external environment
3) Management of technological organizations and technological change in times of high competitive pressure
4) Management of R & D and engineering projects
5) Management of human resources under conditions of rapid techno-logical and social change

Many workshops and reports of the late eighties concentrated on the major issue of that decade, primarily that the industries of the U.S. were losing competitiveness and marketplace standing in both the domestic and overseas marketplace. Organizations were not yet in tune with opportunities presented by a new technological revolution with greater potential impact than the Industrial Revolution.

The reports of the MOT workshops in the eighties and early nineties also stressed the importance of the creation of a collaborative domestic effort between industry, education and the government. This collaboration focused on the need to pursue new ways to develop, transfer and apply technology in order to improve the U.S. position in the global economy.

About ten years has passed since early organized efforts to define the MOT discipline and its place in industry and academia. A framework was created for the field and many institutions responded by establishing curriculum and programs (Khalil 1997). Several problems with the new educational programs have emerged. These include a lack of standardization, inability to integrate courses to better demonstrate the relationship between all topics, and the need for practice oriented education. These deficiencies must be addressed within the Universities. In addition, MOT education must address the need of students' for a program which is flexible to maximize their career opportunities, yet focused to ensure a common body of skills and understanding needed for technology management.

Many changes in the business environment have occurred since the eighties. Efforts to increase the U.S. position in the global economy are being influenced by the understanding that more international issues are encountered by many corporations. Additionally, based on research and corporate internal makeovers many changes within organizations have been occurring during those ten years.

To discuss those changes and identify new issues and priorities, the National Science Foundation, The International Association for Management of Technology (IAMOT), and University of Miami began preparation for a co-sponsored workshop in 1998. The area identified as most influential in advancing business competitiveness in the next decade is the ability of corporations for agile adaptation including clear understanding and knowledge of how to embrace the continual change in technology. This change requires greater attention to the need for education focused on a dynamic model of business. There is a need to create new and more useful education for management and all levels of human resources capable of serving technological corporations. Industry needs employees that are dynamic and are able to react and adapt to the changes inherent within technology and industry today.

In preparation for the 1998 NSF/UM workshop attendees of the Seventh International Conference on MOT, held in Orlando, Florida on Feb. 16-20, 1998, were given a survey containing the following questions:
• Is there a market for MOT education?
• Is demand being met?
• What should be the content of MOT?
• What needs to be done?
• How should educational institutes respond?

The tabulated responses brought up several important issues. The results included the unanimous response in the affirmative to the question of "Is there a demand for MOT education?" When responding to the question of demand for MOT education being met, the majority of the respondents indicated "so far, no," although there

were a few answers that the demand was being somewhat, but not fully met. As to what needs to be done within the MOT, respondents simply stated that MOT needs to "get out of the box" and begin as a field of education in its own right. This also indicated that there was a need to formulate a MOT theory and develop more practical tools for the MOT. Educational institutions should then respond with the addition of more MOT programs, primarily based on increased industry input. These questions provided a nice overview of the needs in MOT.

At the 7th international conference the issues, priorities and questions were also presented in a MOT education workshop. Conference attendees were able to listen to a panel of experts discuss industry needs for MOT education and pertinent issues influencing the advancement of this field. Attendees were then invited to participate in discussion and express their views on the matter. The discussion at this workshop was summarized in over 50 brief points, some of which included:

- There is a definite paradigm shift in industries which requires a specially educated and trained human resource.
- Current undergraduates are not prepared for the new business environment.
- Current MBA programs are more suitable for a static environment than for the dynamic environment of the new century.
- An MOT trained individual should be versed in technology base of the enterprise, understand the impact of technological change, develop good communication skills, excellent computer skills, be able to work in teams, have strong ethics and values, understand global cultures, appreciate diversity, receive cross disciplinary course work , understand organizational structure to develop a wide view of the company, be able to integrate knowledge and resources, be able to think "out of the box," understand the macro and micro view of the business world, understand the sociology and the context of MOT, appreciates the need for strategic thinking and operational efficiency, know technical methodologies that enhance competitiveness, receive practical training to develop tacit knowledge and much more.
- There is a need to create job descriptions, career ladders and to legitimize MOT as a recognized field within corporations and universities.

- Organizations should concentrate on core competencies and the conversion of them into core products, the optimal utilization of resources, knowledge of managing information throughout the world, how to select the winning technology, the development of a technology culture, integrating technological and business strategies, the acquisition and exploitation of appropriate technologies and the development of a vision for the future.
- Academic institutions need to re-engineer their academic procedures, develop MOT faculty, change institutional structure, reward systems, permit stronger interdisciplinary and cross disciplinary interactions.
- Some participants questioned the validity of the generally accepted assumption that Management of Technology concepts apply equally into manufacturing and service. People in the service industry seem to feel that there are some differences in the application of MOT in the different sectors of the economy.

These issues were discussed in greater detail at the 1998 NSF/UM workshop held at the NSF Headquarters in Arlington, Virginia. Several recognized MOT experts were invited to attend a more focused discussion of the issues. In preparation for attendance, these experts were asked to discuss their views in position papers that explore the future needs and direction in which MOT would travel. The questions for this group included: what are the critical issues influencing MOT in the 21st century? What are the drivers for change in the 21st century? What are reverse drivers? And, what needs to be done to advance MOT education and practice? These position papers, together with the issues raised by participants of the MOT education workshop of the Seventh International Conference on MOT, and with the results of a DELPHI study conducted by George Scott (1998), were bound and presented to the selected panel of experts attending the NSF/UM workshop. This material provided a background and base for discussion at the workshop.

The position papers recognized that there has been much MOT research, although most of the results of this research have not been directly applied, nor utilized by today's primary stakeholders: industry and education. Both groups of stakeholders have responded, but neither one to the optimal potential. Industry needs practical techniques and education still seems to focus on existing compartmentalized struc-

tures in schools of business and engineering. In other words two things still have not been accomplished: 1. Education and research have not been able to provide industry with what it needs. 2. Universities have not changed their educational structure to the manner which would best fit a MOT discipline.

IV.   SPECIFIC DRIVERS OF GENERAL TRENDS IN TECHNOLOGY AND MANAGEMENT

Participants at the 1998 NSF/UM workshop identified many issues as the primary drivers of change in the 21st century. These drivers were classified under seven main topics.
1) Technology
2) Changes in Business Environment
3) Communication, Integration and Collaboration
4) Strategic Directions of Industry
5) Changes in Organizational Structure
6) Financial Sector Structure
7) Education and Training
Each of these key factors are comprised of objectives and observations which further define their place in the MOT.

1. TECHNOLOGY
Intensification of changes in technology are projected to increase into the next century. The following are some key technological indicators expected to influence industry and the business environment into the future:

1.1. Diffusion of information - The rapid diffusion of information and communication resulting from technological advancements. The Internet, for example, is an avenue for the provision of extensive amounts of raw information, accessible by many people. This diffusion of information is also seen in the use of Intranet within organizations, providing better processed information throughout an organization. The diffusion of raw information (e.g. newsgroups on the Internet) is different than the diffusion of packaged and processed information. The interaction can be two way or multi-way and will foster collaboration in departments within organizations as well as between organizations well into the future through enhanced communication.

1.2. Fusion of technologies - The enhancement of performance of technology as a whole by the advancement of technology and technology sharing among various disciplines and concentrations. This fusion of technologies, for example the development of multiple products that fuse material, mechanical, electronic, and manufacturing technologies, will lead to the emergence of even greater complex technologies. This in turn will require engineers and managers to be wired together and adaptive to a multi-disciplinary world.

1.3. Multidisciplinary change - An increased technological complexity drives the environment towards multidisciplinary cooperation, incorporating technological changes within organizational activities based on interdisciplinary knowledge and dynamic needs. This will require cross-disciplinary training, cross-cultural training and an emphasis on collaboration with sensitivity to the needs of technology and the people working with it.

1.4. Rapid growth areas, emerging technologies - It is becoming apparent that the two sectors most likely to be leaders of change in the next Century are the molecular biology field and the computer information system/communications field. Industries such as healthcare, agriculture, and genetic- based industries are likely to be privy to great changes in technology within genetic engineering, biotechnology and nanotechnology. Similarly, the manner in which computer and information technology have already changed organizations demonstrates the power and desire for these organizations to utilize information and communication technology for increased efficiency and competency.

1.5. Cost and complexity driving collaboration - The cost and complexity of technology, as well as the drive to maintain a competitive edge prompts increased pressure on corporations to respond by creating new technology. Pressures will lead to collaboration among companies who have been traditional rivals. They will work together on the development of new technology in order to save time and money. Cost, complexity and time issues will also lead to strategic involvement of government in collaboration with industry and academics, as well as an increase in funding of research in critical technology areas in order to enhance national competitiveness.

2. CHANGES IN BUSINESS ENVIRONMENT

2.1. Emergence of multiple stakeholders - The emergence of multiple and more involved stakeholders leads to the need for a manager who is able to deal with demands of a diverse array of issues as well as diverse stakeholders. In addition to the traditional stakeholders of investors, managers and employees, the list has expanded more recently to include customers and suppliers. Investors are no longer the only stakeholders in the performance of business enterprises. The increased stakeholder list also includes such non-traditional groups as environmentalists, governments and global communities. Managers in technology-based organizations should become more educated and in tune with this gamut of stakeholders in order to respond effectively to their needs.

2.2. Knowledge generation - The business environment must rise to the challenge to ensure that the systems responsible for the generation of knowledge are effective. Corporate research labs today, such as the GE and Bell labs, seem to have changed - some argue that these labs have become weaker in the generation of new knowledge than when they were 20-30 years earlier. Similarly, government and defense research laboratories have come under pressure following the cold war era. Operational and research subsidies are no longer what they were and these laboratories are discovering the need to adapt to a changing environment. The challenge to policy makers and the industrial community alike is to discover ways of ensuring that knowledge is adequately flowing through the knowledge generation system. Knowledge generation is a key entry point for effectively managing technology, and must be supported by innovative policy development and a resurgence of research funding in the development of new technology.

2.3. Intellectual property rights - Intellectual property rights in fast-changing and multi-faceted organizations will create a legal and logistic challenge to corporations. The need for a better structured Intellectual Property Rights (IPR) agreement has been recognized by many organizations. Today, IPR agreements grow more complicated. The development of a product or service today involves many facets, the direct result of multi-disciplinary and probably multi-company involvement. For example, in the case of a product's development that involves 20-30 different com-

panies, such as multimedia communications - the one corporation which desires to obtain a license for this product will need to compensate all companies involved in the development of the end product. Multimedia communications can involve components including speech, video, text and other technologies that do not have the same owner. Additionally, the contents within the end product have different producers and owners. Negotiating with all the stakeholders, the owner of each intellectual property, will require significant effort and a broad understanding of multiple technologies and stakeholders.

2.4. Information and communication security - New and enhanced security and legal issues drive the need for a change in corporate records and information systems. The need for corporations to master communications technology is particularly true because of the quantity of corporate records which are stored in cyberspace. The responsibility for this information holds potential legal repercussions, including breach of security, antitrust action and legal action against the corporation. For example, memos on Internet can be used as evidence in trials and ultimately top executives are held responsible for their corporation's activities. The recent antitrust legal action against Microsoft is one example of this problem.

2.5. Globalization – Global stakeholders and competition will encourage more global alliances. A dynamic global marketplace will create the need to educate members of the organization in international business practices. The understanding of international economic, political and cultural issues will help in the global marketplace.

2.6. Outsourcing - There is an emerging trend in industry towards greater dependence on the outsourcing of some aspects of technology to small and mid-size companies. Worldwide this will require greater collaboration, mergers and joint ventures in order for companies to compete effectively.

2.7. Multiple parties involved in innovation - Multiple ownership by competitive corporations working in the same technology through participation in an alliance will increase in the future. Corporations interested in shared technology will need skilled

managers able to coordinate involvement in multiple projects while at the same time incorporating the various interests of each stakeholder.

2.8. Technological imperialism - Technological imperialism will emerge into all areas of business disciplines. Finance, marketing, innovation, engineering and public relations all use technology and innovation as the common core to compete. Innovation competition among all business processes will be a dominant factor in determining business success. MOT is the arena that is most intensively involved in the study of the innovation process as well as in the development of multi-disciplinary training.

3. COLLABORATION, COMMUNICATION, AND INTEGRATION

3.1. Change in the organizational culture - Collaboration among departments and organizations assumes greater importance as technology changes rapidly. The globalization of organizations highlights the need to deal effectively with various employee and consumer cultures. The organizational culture must react to global needs with sensitivity to the cultures, economics, and politics of each stakeholder group. The MOT within each culture will be inherently different.

3.2. Collaboration among companies - Collaboration among companies will consist of increased global alliances, joint research, development and production projects. The projected use of supply chain management, through the integration of suppliers, production and distributors will increase.

3.3. Internal collaboration - The integration of departments within the organization will build a better synergy and create a unified organization working collaboratively around an end product.

3.4. Multi-disciplinary culture- Increased technological complexity demonstrates the need to create a multi-disciplinary culture. For example, electric commerce involves many components to incorporate: technological, legal, financial and cultural. The key of this driver is to not simply rely on the straight business or straight

technological aspects of an industry or trade, but to incorporate components that will increase the marketability and competitiveness of the corporation.

3.5. The sophisticated consumer - As consumers become more "sophisticated" and better educated in today's technological advancements, the need for the industry to market and create technology to satisfy the consumer will grow. In order to create even more new products to cater to an increasingly global consumer requires better understanding of the consumer, more accurate market research, closer interaction with the customs of the global marketplace and mass customization.

3.6. Government collaboration - A more collaborative relationship between government and business will occur. This cooperative effort will lessen a hands-off, adversarial or policing role which government previously had with industry.

3.7. Internet as a communication revolution - The explosive use of the Internet, have caused a "bottom-up" revolution, where communication within companies and communication between the business and the customer has been utilized in order to foster business growth. An example is ordering a car on the Internet by linking the consumer, manufacturer and suppliers in an integrated system.

3.8. Compartmentalism to wholism - Current engineering, management and education practices tend to compartmentalize activities and functions within the enterprise. Traditional engineering management structures consider linear flow among product technology (R&D), manufacturing/operation and sales. The recommended change is a holistic approach to break the barriers between compartmentalized functions. A common platform among all functions can be created by the use of Information Technology. The Internet will tie together departments into an integrated system. This system can be extended to include marketing and other activities. Business organizations will increasingly integrate all activities and functions to create greater returns on investments. Holistic management technology issues will address the return on investments through the optimal corporate activity.

4. STRATEGIC DIRECTIONS OF INDUSTRY

4.1. International policy issues and the role of multi-nationals

4.1.1. *First phase* - Following the industrial revolution the world had gone through several phases of change before World War II. During the era of colonial dominance, wealth was channeled towards the major world powers.

4.1.2. *Second phase* - After World War II, the second phase of international policy was dominated by the politics of the Cold War period and wealth was channeled to industrialized countries with technological know-how.

4.1.3. *The third phase* – This international policy phase presents a new world order where countries need to work together to increase the economies of all. Nations around the world have started focusing on economic growth, as evidenced by the number of countries that have signed for the General Agreement on Tariff and Trade or applied to belong to the World Trade Organization. Technology is a major driver of economic growth. The economic development of the under - developed countries and the issue of wealth distribution has become a global problem: how to manage technology in a global economy.

4.1.4. *The next phase* - The issues as we go forward are not only the economic growth of individual countries, but how to deal with social justice around the world. Individual governments cannot do this on their own. A strong role must be played by industry; multinational organizations seem to be on the forefront driving globalization. Public policy leaders in countries with developed economies, such as the U.S. and Europe, as well as managers of multinational corporations, have a role to play in order to allow countries with developing economies to be a part of the global economic growth movement. Additionally these countries and multinational corporations should exhibit sensitivity to the local conditions and cultural characteristics. Countries with developing economies should be allowed to evolve and grow, otherwise a collapse of the global economy may occur. At this time there is not adequate worldwide government for this driver. Ideally, strategy makers should display a shift in thinking from simply creating wealth for their own constituencies, to concern about the distribution of wealth.

4.2. Strategic planning - Industry should recognize the importance of strategic planning and create an emphasis on the importance of in-depth strategic plans. Strategic plans should not just be a bunch of completed forms, but should incorporate planning for the future that leads to a source of sustainable advantages. The need to anticipate change and growth is inherent in the field of technology. To translate anticipated change into the overall planning and competing effort of the company is of prime concern.

4.3. Harnessing technology - A better use of technology gatekeepers to harness technology and the use of virtual simulations will enhance strategic planning. New organizations will emerge to collect the information, act as a think tank and disseminate it to other organizations for use in their planning process. Whatever gives a corporation or industry adequate information and ideas about other companies and about their competitors' strategies and plans will be highly desirable.

4.4. Intellectual capital - Strategic planning must incorporate not only tangible, but intangible assets that are based on a new core concept for harnessing organizational capability. This planning process would force an organization to recognize intellectual capital and tacit knowledge. This process will also help to define the cultures of the organization and those of employees and customers.

4.5. Small business growth - Today there is an emergence of a distributed economy as the change in technology is fueling entrepreneurial activities and leading to growth in smaller businesses. The proper use of these smaller businesses can contribute to the overall growth of technology and the economy. This may also lead to the creation of virtual or hollow corporations with a stronger dependence on outsourcing; potentially leading to the re-emergence of the cottage industry similar to those of the early industrial revolution. The cottage industry of the next century is more likely to be closely linked through informatics.

4.6. Shorter and closely combined business technology life cycle - It is important for a business to recognize the limitations of each product and the services which it provides. Industry must also recognize that replacement technology is often being developed while the current product model is being marketed. The shape of the traditional S- Curve of technological progress is changing for some industries, such as software where growth may be suddenly halted by the emergence of a new generation of software. Rapid changes in technology have made it important to begin replacement or improvement technology immediately following development of new products. This is done in anticipation of the technology evolution so that one is ready to jump from one product to the next as the technology matures and reaches its limits. Shorter technology life cycles are creating a greater need to closely integrate business and technology strategies.

5. CHANGES IN ORGANIZATIONAL STRUCTURE

5.1. From permanent to temporary - There is a growing trend to move away from fixed, permanent organizational structure to a more temporary and flexible structure. Companies are likely to keep a core staff and seek temporary employees to supplement new project developments or additional needs. The assembly of ad hoc organization structures to meet a specific need or a special technology is anticipated as a future growth area. Organizations may be assembled to meet specific needs or special technology and disbanded as the technology changes or the need disappears.

5.2. New business model - Organizations are increasingly changing their structure from a vertical hierarchy (the traditional model) to a more horizontal or network model. The need for an organization to realign organizationally in order to create a flat organization, consisting of fewer management layers and creating a more interactive network model, permits greater interaction as well as a better flow of information and facilitates the process of technological innovation.

5.3. Integration/alliance - There is an expectation of greater integration among and within organizations, especially aided by the computer/information technology and the incorporation of Internet. Business alliances and greater reliance on other organizations will occur, particularly among organizations dealing with emergent technologies.

5.4. Mergers/acquisitions - The creation of mergers/acquisitions, particularly in organizations dealing with mature technology, are also likely to occur as corporations realize the benefits to combining technological expertise, economies of scale, and the elimination of organizational duplications.

5.5. Increased move to the service economy - There will be more organizations which focus on the provision of generating and distributing knowledge as a service area. The production of non-physical products and services will grow in importance.

5.6. Knowledge driver - Knowledge is the driver behind supply chain strategies, driving innovations in product, production, distribution and marketing. Organizations which value change will be formed. These new organizations will be dependent upon its employees' ability to utilize computers, information technology, and logistics in a swift, fluid, and organized manner.

5.7. Organizational sensitivity to cultural differences - Corporations' designs will be influenced by cultural sensitivity. What is needed, accepted or rejected in cultures, how swiftly corporations organize to serve specific populations and how to take advantage of what the consumer accepts will vary in both organization and ethnic culture groups. Organizational sensitivity will also force production and marketing for cultural differences.

6. FINANCIAL SECTOR STRUCTURE

There are three related issues for the finance community related to investment in technology. First, the need for different investment frameworks as we move from managing technical projects through to commercial success, where the odds of success may average one in 3,000. Second, the need for better venture capital models and mechanisms. Third, the valuation of intellectual capital and wealth creating capacity of the high tech workers in the information industries as mentioned earlier in this report.

6.1. Innovation in financial sector - New technologies require new financial resources. The question is the ability of financial organizations to innovate in finding financing mechanisms for significant innovations and for financing new ventures.

6.2. Justifying investment in technology - The increased pace of change and complexity of technology creates a need for new techniques to assist venture capitalists in improving their justification of investment in technology. Meanwhile, entrepreneurs should be prepared to deal with the continuous change in technology and the business environment. The development of human skills needed to deal with technological uncertainty will aid in increasing investments for technology.

6.3. How to finance multiple-party innovation - Multiple companies with involvement from multiple countries will necessitate the creation of a structure of multiparty innovation financing. Sharing of cost and benefits should govern the structure of these types of deals.

6.4. Changing in funding trends - National funding policies are currently focused on making certain countries, such as the U.S., a world leader, yet most of today's technological issues have global dimensions. There is a new need to create public policy leading away from parochialism and ethnocentric trends. Public policy must address the global interests versus only country-specific applications. Funding projects on a national scale must be replaced by a trend of funding projects on a multinational scale. Concentration on benefits of projects of global importance, such as global warming and disaster mitigation of earthquakes, is needed. A better way to assess merits and technological potential of projects is needed to permit good accountability and facilitate the change towards global considerations.

7. EDUCATION AND TRAINING

7.1. Change in formal education styles - Industry has been leading the way towards change and organizational flexibility necessary for survival in the 21st century. Although great strides have been made since the eighties, higher education has been lagging behind in adjustments to the dynamic technological corporate environment. The need to adapt to constantly changing technologies is a goal for the

educational arena. The current U.S. higher education model emphasizes learning fast, but lacks depth in its ability to emphasize the role that education plays in the advancement of the overall socioeconomic position. For example, engineering education, while imparting good disciplinary knowledge about the creation of technology, does not provide a graduate with the ability to link their education to the critical need for integration. Nor does it stress the importance of converted knowledge to commercial endeavors that create wealth and advance the economic and social well being of society. The linking of technology creation to the sustainability of economic, environmental and social development has not been emphasized. There is a great need to develop an inter-disciplinary and result-oriented education model providing students with an understanding of where their piece of expertise fits in the puzzle. Educational system evaluation should be judged on its results rather than its input. How education should emphasize the future more than the past in standard instructional models is an issue deserving immediate attention.

7.2. Electronic education

- The new emergence of distance learning and electronic educational delivery will increase. Universities may emerge from delivering only local education to delivering education throughout the world.

7.3. The education needs of people will change

- Multiple degree seekers will emerge, probably leading to a stage where no manager will have only a single degree in the future. There will be an explosion of knowledge and a lifelong learning experience to keep up with this explosion. The need for more technological and managerial education for all managers will be necessary.

7.4. The new business leadership

- A new type of business leadership is needed to run companies of the future. This leadership must focus on knowledge generation and application, emphasis on innovation, integration of organizations, and collaboration. Research into how to harness intellectual resources and technology in order to generate knowledge, convert knowledge into commercial application and capture the returns from the conversion process to create wealth will occur. The essence of MOT is that there is a new type of education in MOT that needs to be promoted.

7.5. The new discipline

- A new discipline model based on knowledge infrastructure integration and cultural acceptance is needed to prepare people for the future of global technology. Multi-disciplinary training for leaders in management and technology is suggested. This new discipline of knowledge integration combined with trans-cultural engineering still needs to be designed. Training in this discipline, which could form the contents of MOT curriculum, is essential for leaders in management and technology.

7.6. Hands-on education

- Learning through hands-on involvement is invaluable for many reasons. There is only so much one can learn from reading a book or hearing a lecture. The experience one gains through hands-on training and involvement offers an invaluable opportunity to effectively deal with managing change. So far even the best schools have not been able to accomplish this in an effective model. A new MOT educational model format needs to emerge in universities.

V. INDUSTRY AND THE NEED FOR A NEW EDUCATIONAL MODEL

While it is important to recognize the drivers for industrial, technological, business and educational changes, it is also necessary to identify both the capabilities and the needs of contemporary industry and educational institutions. In this section we examine the current status of education in engineering and management and the relevance to the changing environment in industry and business as it is today. The world now is different than the time period a decade ago in which MOT was originally discussed.

A technology revolution, the end of the cold war, a global economy, trade blocks such as the European Union and NAFTA and other changes have brought tremendous attention to the field of MOT as well as the fields surrounding it. Unfortunately, despite these changes, educational institutes are still demonstrating traditional objectives and degrees, particularly in engineering and business disciplines. In the dynamic business environment today technology is changing at a very fast pace and competition is based on innovation and creativity. The old factory model is no longer a workable model. Newer models need to be reflected in educational programs. Industry has demonstrated readiness to change practice and organizational structure as a response to the technology changes. Academic institutions are still slow in embracing change both in curricula and in methods of delivery of education.

MOT Education:

MOT education today encompasses a diverse array of stakeholders and customers who will benefit from definition and structure within the field. Current "customers" who will benefit by the creation of a new MOT framework include:

- students
- organizations which hire students
- top managers
- professionals
- supervisors/team leaders

- technical and managerial staff
- external "allies"
- paying customers
- entrepreneurs
- legislators.

Changes and suggestions in the framework of MOT should be directed towards these stakeholders' needs. Meanwhile stakeholders, particularly industry and universities, should cooperate to create more research opportunities in MOT and more communities of learning and practice. Results should be disseminated to industry and education with an explanation of how MOT can be applied and what it means to them.

John B. Bush, Jr. (1998) identified three ways in which education in MOT can be directed:

1. Direct education of actual or potential technology oriented managers and employees "to identify a palette of techniques that will be optimally effective in the context which they practice"

2. Indirect education of actual or potential managers about the use of MOT while focusing on the understanding of "how to integrate technology into organizational strategy."

3. For all others not directly concerned within the MOT, a brief education about the importance of incorporating MOT within organizational structures is also needed.

In order to further MOT, Bush states the need to benchmark and increase the efficacy of MOT research including publication of results of MOT programs, thus allowing the review of pros and cons to various practices through discussion groups; the participation of researchers of MOT in technology management focused workshops and meetings; and the encouragement of collaboration between researchers of MOT in the development of focused workshops directed to both academic and industry groups. Additionally, Bush identified the need to create specific and direct criteria in the research and instruction of MOT.

Industry:

Industry operates in a dynamic and fast changing environment. However, the traditional model of industry since the time of Frederick Taylor is centered around a factory system divided by function and job categories, advocacy of standardized designs and only tangible assets considered as representation of where the company financially stands. Investment decisions are frequently made on the basis of the discounted cash flow methods and projects are justified on the basis of returns on investments. The traditional business process is more linear and based on explicit information and the output is based on an assembly line model. Management was responsible for designing the workers' task, and controlling the operation. The products are produced with little or no involvement by the customer. These models originally shaped by Taylor's concepts of scientific management were suitable when technology was relatively stable.

Modern technology-based corporations have a dynamic environment and different needs. Despite this fact internal corporate education, as well as educational institutions are delivering education which is suited to a non-changing model. There are many technological opportunities that can be enabled by the explosion of knowledge and technology that are not captured through existing corporate systems. It has been observed that although there is an exponential growth of knowledge, corporations still seem to have a linear conversion of knowledge to wealth.

There is a pressing need to develop a system that will provide the maximum potential for the conversion of knowledge to wealth. Researchers need to create and disseminate more research in MOT and disseminate it to industry. Human resources departments need to be educated in new methods with which to seize changing technological opportunities and to convert the knowledge into wealth.

Industry today uses both explicit and tacit knowledge to drive their business. Global cultures and opinions by both external and internal customers (customers and employees) play a bigger role in the product end results. All changes and discussions in MOT must realize the diverse industrial participants needs.

Education:

There is a gap between what education is needed by the stakeholders and what is being made available. Search for a better education model has included the identification of a need for a broad discipline that William Miller (1998) proposed to call Knowledge Infrastructure Engineering (KIE). This discipline incorporates a combination of MOT, innovation and knowledge. Since the new key driver of the economy is the innovation process, KIE can be directed to developing the needed innovation structure and techniques and to developing new leaders for industry, technology growth and expansion.

In the 1980's When the original call for education in MOT was made, the response of educational institutions was to compartmentalize the education into existing programs in engineering or business schools. Some institutions attempted more interdisciplinary programs involving interaction between business and engineering schools. Cultural clashes between educational influences seemed to impede the progress of the intended enhancement of educational opportunities for students. These difficulties arise from the rigidity in structure of the educational institutions and their slow pace of change compared to industry. This adds to a shortage of trained faculty in the newer paradigms of business. The opportunities to maximize return of technological advancement still lies ahead of us.

The need for a new academic discipline is echoed by many. Several scholars in the field have the view that as long as MOT does not have a unified framework and is not established in the traditional departmental structure of most universities, it will not flourish as a field of study.

Several workshop panelists feel that there are many opportunities directly enabled by the explosion in knowledge and technology that both have not been and currently are not being captured by the existing systems of education. Universities are not producing individuals adequately prepared for the technological work force. The field of education needs to create a work force with the ability to take advantage of opportunities presented by the technological innovation process.

The need for development of a stimulating educational process in the area of MOT is a growing national necessity. The development of a MOT educated work force is imperative to the corporation's future. To be effective the new academic models should be experience based and not rely solely on the development of models from theory. These models should rely on the input of industry itself in the development of practice-oriented education. A change must occur where institutions implement new theories and models demanded by actual practice of industry in the current changing environment.

Innovation management is taught apart from the social components of MOT, in science, engineering, and business schools. The need to integrate these innovation management techniques and form a new discipline is apparent.

The Contents of MOT Education

An integrated curriculum- including natural science, social science, engineering, business, and industry practice is recommended. This is depicted in figure 1.
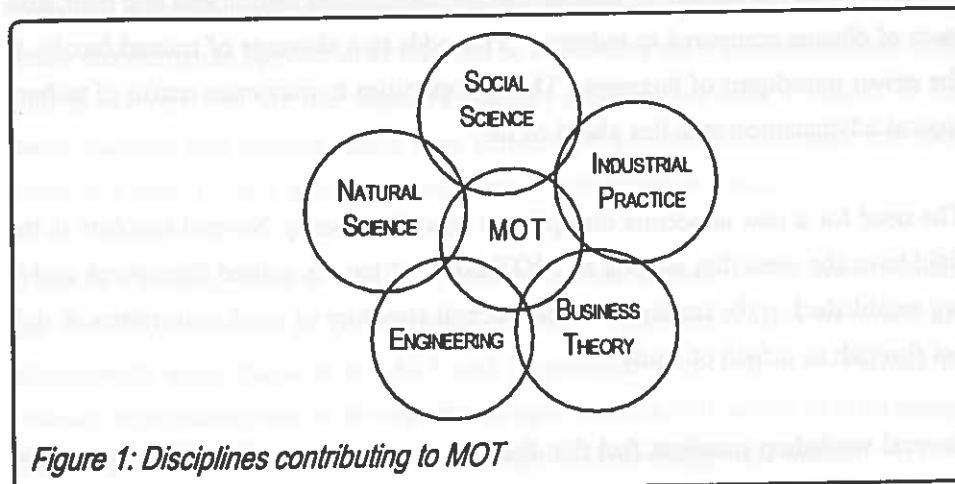

Figure 1: Disciplines contributing to MOT

Education needs a unified framework around which planning at different levels can take place. Today we need to stress the context and connectivity among the various issues surrounding MOT. We need to establish a new framework under which we can develop MOT curricula. Following is a chart developed by Graham Mitchell that presents a framework for MOT education.

Mitchell argues that most existing course contents in the MBA and Engineering programs tend to concentrate on the established technology and business issues. Few programs may have scattered courses in entrepreneurship or high-tech start ups. There is a need to develop a more comprehensive integrated curriculum to deal with all the key issues facing business in the 21st Century as suggested by the framework in Figure 2.

KEY ISSUES		
	TECHNOLOGY	
	Emerging	Established
Established	Threats: Market position, competitive position, (attacker's advantage.) Opportunities: New markets, new industries, for the prepared and positioned firm, through MOT Innovation.	Challenge: Traditional management challenges intensified by shorter product/market cycles. Incremental and continuous improvement, re-engineering, quality. Opportunities: New and improved products, services and systems, through innovative application of new tools, models, systems, i.e. the new Technology of Management.
BUSINESS		
Emerging	HI tech start up. Entrepreneur financing, marketing, management. Management of technological innovation. Venture capital and valuation. Source of industries. New industries and national advantage.	Entrepreneurship in low-tech business and traditional business.

Figure 2: Framework for developing integrated MOT program.

Beyond this Mitchell argues that this broader perspective, as we move from bottom left through top left to top right, describes the corporate Chief Executive Officer's (CEO) interests in technological innovation and its impact. The issues in these quadrants address the nurturing and assimilation of emerging technology generated outside the corporation, its development inside the corporation and its implementation and deployment in operations. The integration of this system, rather than a narrow focus on specific areas, represents a more appropriate focus for the future of MOT.

Tarek Khalil proposed a number of areas that create the core knowledge for a MOT curriculum (Figure 3). He argues that a comprehensive MOT curriculum should address the topics listed which integrate knowledge from science, engineering and management with a focus on creation of wealth, prosperity and quality of life.

A DELPHI questionnaire research study, conducted by George Scott (1998), provided insight to management issues within new product development in high-tech companies. Through this study a list of top ten MOT problems as seen by the 58 surveyed academic and industry participants in the study was developed. These top ten issues were:

- Strategic Planning for Technology Products
- New Product Project Selection
- Organizational Learning about Technology
- Technology Core Competencies
- Cycle Time Reduction
- Creating a Conducive Culture
- Coordination and Management of New Product Development Teams
- Technology Trends and Paradigm Shifts
- Involvement of Marketing Groups
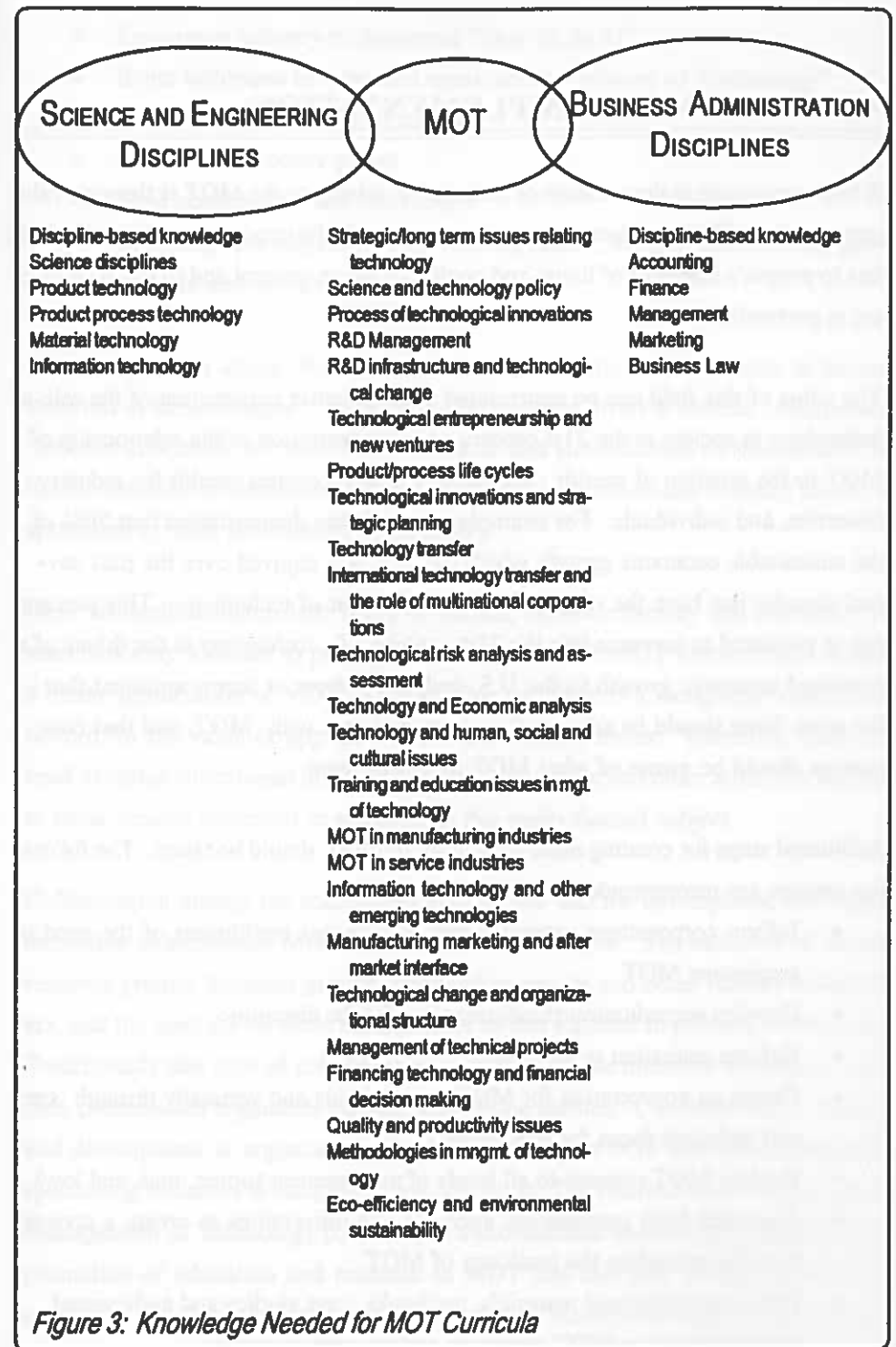- Customer/Supplier Involvement

SCIENCE AND ENGINEERING DISCIPLINES	MOT	BUSINESS ADMINISTRATION DISCIPLINES
Discipline-based knowledge Science disciplines Product technology Product process technology Material technology Information technology	Strategic/long term issues relating technology Science and technology policy Process of technological innovations R&D Management R&D infrastructure and technological change Technological entrepreneurship and new ventures Product/process life cycles Technological innovations and strategic planning Technology transfer International technology transfer and the role of multinational corporations Technological risk analysis and assessment Technology and Economic analysis Technology and human, social and cultural issues Training and education issues in mgt. of technology MOT in manufacturing industries MOT in service industries Information technology and other emerging technologies Manufacturing marketing and after market interface Technological change and organizational structure Management of technical projects Financing technology and financial decision making Quality and productivity issues Methodologies in mngmt. of technology Eco-efficiency and environmental sustainability	Discipline-based knowledge Accounting Finance Management Marketing Business Law

Figure 3: Knowledge Needed for MOT Curricula

VI. VISION FOR IMPLEMENTATION

A key component in the creation of a discipline related to the MOT is through value propagation. There is a need to create awareness of the importance which this field has to people's standard of living and quality of life in general and to the stakeholders in particular.

The value of this field can be appreciated through better explanation of the role of technology in society in the 21st century and demonstration of the relationship of MOT to the creation of wealth. Technology is what creates wealth for industry, countries, and individuals. For example, research has demonstrated that 50% of the sustainable economic growth which the U.S. has enjoyed over the past several decades has been the result of the advancement of technology. This percentage is projected to increase into the 21st century. As technology is the driver of a sustained economic growth to the U.S. and everywhere, it seems apparent that the work force should be adequately prepared to deal with MOT, and that consumers should be aware of what MOT means to them.

Additional steps for creating more sensitivity to MOT should be taken. The following actions are recommended:
- Inform corporations, agencies and educational institutions of the need to emphasize MOT
- Develop accreditation/standardization for the discipline
- Reform education in the MOT
- Create an appreciation for MOT across fields and vertically through special technical focus for specialists.
- Explain MOT concept to all levels of management (upper, mid, and low)
- Approach both professional agencies and universities to create a consortium for spreading the teachings of MOT
- Prepare professional materials, textbooks, case studies and audiovisual material to use in MOT education and training programs

- Encourage industry to document "How to do it?"
- Invite historians to write and speak about "History of Technology"
- Create communities of practices
- Create an advocacy group
- Hold conferences and workshops
- Encourage participation of accrediting bodies, funding agencies and government and private policy making groups

Another question arises: How are we to entice industry and education to become involved in these changes? A strong public relations effort is needed. Additionally resource allocation for more MOT research and subsidization of new models for human resource development within educational institutions and industry should be sponsored by both government and industry.

More in-depth research into MOT is needed, however faculty and university researchers may not want to participate in the process of MOT research until there is a better appreciation of MOT as a discipline and there is a recognized institutional reward for the value of applied work in the industry arena. Therefore, there is a need to entice educational institutions to provide tenure and other attractive benefits to those faculty interested in researching this multi-faceted subject.

Collaboration among the stakeholder community and the development and implementation of a common MOT framework will be helpful. The inclusion of various research groups, business groups, engineering groups and other various stakeholders, and the need for all these communities to join together in projects is important. Traditionally this type of collaboration occurs under the umbrella of funding agencies, professional organizations, and accrediting entities. Currently MOT research and development is organized under the leadership of NSF and other institutions sponsoring research, development, and education. The International Association for Management of Technology (IAMOT) is a professional association dedicated to the promotion of education and research in MOT and can play a significant role in promoting this field. Industry should certainly be heavily involved with this effort.

In order to increase MOT awareness, the following types of groups also need to be involved: the American Association for the Advancement of Science, Project Management Institute, the Business Higher Education Forum, Government University Industry Roundtable, National Research Council, the National Science and Technology Board, the Industrial Research Institute and other engineering and business professional organizations.

Additionally, the involvement of CEO's of business organizations is necessary. Increased involvement with the Conference Board and the Business Roundtable should be sought. The development of MOT public relations materials could assist in the generation of further involvement of administration and faculty as well as the increasing of awareness through a potential Advocacy Group of University Presidents, deans and corporate Chief Executive Officers.

It is essential that the NSF educational program becomes further involved in the advocacy of education for the new MOT environment. The NSF has education funding and could develop educational materials for use as modules in business or engineering schools in order to further develop curricula. The MOT community must demonstrate the demand and propose actual ideas to justify funding this sort of educational development by the NSF.

The development of internships and apprenticeships in order to further enhance the education within the field of MOT is needed. This experiential learning is important due to the constantly changing environment within technology. The apprenticeship has been known throughout the ages. With MOT it is no different. An actual experience within a fast -changing, technology-driven corporation allows for a dynamic and hands-on learning experience that will create a better understanding of the technologically driven business environment.

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