Recent Developments in Management of Technology: Education and Training

Qazi Moinuddin Abro, Zahid Ali Memon

Mehran University of Engineering and Technology Jamshoro Sindh Pakistan, Pakistan

ABSTRACT

The rapid emergence of powerful and innovative technologies in information technology are making management of technology a critical task in virtually all organizations and is attracting the attention of practitioners and scholars. Several universities offer a wide range of graduate as well as undergraduate programs in MOT. These programs have originated from various academic schools and disciplines (business, engineering, public policy, etc) creating considerable diversity of focus, themes emphasized, courses and methods of offerings. The rise of these programs, in part, reflects the growing need for managers and technologists who are able to understand, contribute to, and manage a wide variety of technology-based programs and organizations. In addition, the large number of MOT research journals, professional associations and national/international conferences point to the rapid growth of this field.

This paper will examine the impact of information technologies on the MOT; by focussing on recent trends in provision, major MOT curriculum focus, and then compare these trends with the emerging trends in the MOT research journals of the last decade.

Total 74 universities worldwide have been selected for the research. Some recommendations and observations about the future direction of the field will also be made.

Keywords

Management of technology, Information technology, Education, Training, Knowledge Management

1 INTRODUCTION

Technology is a major driver of global economic development and industry is increasingly seeking more and more effective ways to manage these existing and emerging technologies; such as biotechnology, telecommunications, manufacturing, computing, and life sciences etc. Given the importance to these new technologies in today's global economy, people who are competent in these fields and companies that are at the "cutting edge" of these new technologies should be able to thrive in this environment. However, several companies with excellent technologies fail to reach their market potential because of the failure to convert their technological capabilities into a business advantage (Mignogna 2002). Similarly, many excellent engineering and science graduates face "glass ceilings•" in their careers due to lack of a business acumen and their inability to capitalize on their technical capabilities. On the other hand, university graduates who can operate effectively across the boundaries of engineering, science and business often have career opportunities superior to those not adept at extending themselves beyond their primary professional or technical domain. Indeed, new skills and knowledge in information technology are called for as companies and markets require managers to perceive and understand how these technologies can provide the productive/competitive capabilities to the businesses (Ulhoi, J. P., 1992). To address the demand for skilled technology managers, several universities throughout the world started formal programs in MOT in the late 1980s and early 1990s. These programs prepare graduates to work at the confluence of technology and business and to provide leadership in formulating and implementing corporate technology strategies.

Due to the rapid emergence of information technology the issues and topics of concern change frequently and it is important for educational institutions to monitor and respond to these developments rapidly. It is this diversity, however, that makes it all the more important that we take a step back and identify some of the common as well as different issues and themes underlying the various MOT programs as well as MOT research.

This Global study on MOT Programs was conducted by selecting the 74 universities worldwide. The study aims at assessing the state-of-the art of contemporary MOT education, training and research by exploring various dimensions of these programs.

1.1 Research Objectives

The objective of this paper is to examine the emerging trends in MOT education and training globally regarding major program themes, anticipated program directions, and the various program management issues encountered in the field.

At the first stage we will identify the emerging themes/trends in the MOT schools as well as MOT research journals and then will compare these trends to

• "An unacknowledged discriminatory barrier that prevents women and minorities from rising to positions of power or responsibility, as within a corporation".

identify the common and different trends in MOT pedagogy and MOT research to assess some future directions of MOT programs.

2. DATA COLLECTION

In order to reach the target population, an internet based search of the different universities, which are providing MOT programs in their different programs all over the world were identified. The Schools offering technology-management-related courses in MBA programs were also identified from the financial times global MBA ranking 2004 (FT Global MBA Ranking 2004). The major MOT-related journals, conference papers, and organizations such as International Association for Management of Technology (IAMOT; www.iamot.org), Institute for Operations Research and Management Sciences (INFORMS; www.informs.org), Portland International Conference on Management of Engineering & Technology (PICMET; www.picmet.org), Academy of Management (http://www.aomonline.org/) etc were also selected in order to get the comprehensive overview and a complete list of the MOT providing institutes worldwide. The total sample population size was 74; consisted of 36 US (49%), 18 UK (24%) and other 20 universities from Australia, Canada, Asia and European countries.

3. DATA ANALYSIS

The collected data is converted into the spreadsheet data columns so that the analysis of the data could be available. The data analysis was done by using the SPSS software because in this way the frequency and percentages of the data can be calculated. Where ever the Microsoft Excel is also used to draw some pie charts.

3.1 Types of MOT programs

A majority of the MOT programs **(54%)** were administrated by business schools and it seems that the rate of growth is also increasing. Engineering schools administered approximately **(30%)** of the MOT programs. There are a few programs offered jointly by the Business & Engineering Schools **(4%)**. Other entities **(12%)** included research schools (Like SPRU, University of Sussex, UK), school of computing, specific institutes housing MOT programs etc.

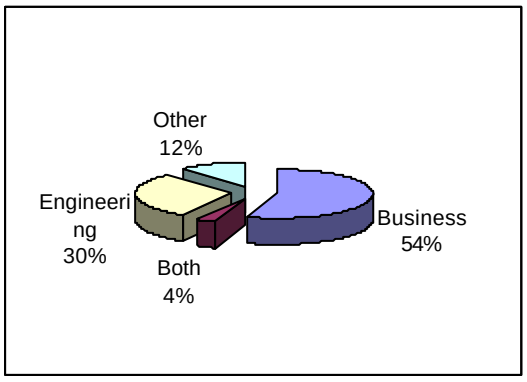

Figure 1: Type of MOT Program

The numbers of MOT programs offered jointly by the Business & Engineering Schools are fewer. As MOT is a multidisciplinary field, which, connects the engineering and business management fields to each other. So, it is important to have some MOT programs jointly offered by both engineering and business schools. This was also included in the primary recommendations, which were made in a workshop (1987) reported by the National Research Council (NRC) "The Hidden Competitive Advantage", *"the knowledge and practice gap between engineering/science and business management be bridged"*.
(Kocaoglu 2003) also reveals that, *"there are a few joint programs with Engineering and Business Schools, so there is a still need of increasing these joint programs."*

There are a less number of programs, which has a multidisciplinary, or a research base in this area.
Business schools administrated a majority of the MOT programs and it seems that the rate of growth is also increasing. In business or management schools, MOT is offered both as an exclusive degree program as well as an MBA program concentration.

3.2 Method of Program offerings

MOT programs are offered more on a fulltime basis **(64%)** than on a part-time basis **(30%)**, and there are some schools which are offering MOT programs through distance learning **(6%)**. Generally, it was observed that MOT programs are provided either on a full-time or a part-time, rather than a mixed (fulltime/part-time) program offering.

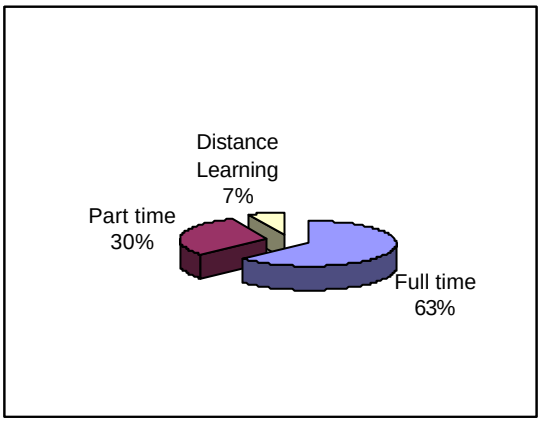

Figure 2: Method of MOT program offering

It is observed from the above findings that MOT programs are offered more than full time basis than part time basis and even a very fewer MOT programs are world wide been offered through the distance learning. It seems that a new trend through the long distance learning of the MOT programs is also increasing. A few schools in the U.S. and in U.K. have successfully deployed the latest information and communications technologies to incorporate distance-learning component in their MOT programs and there by enhance the growth. The most of the universities in US are using the latest

tools of distance learning for example: Black board, WebCT etc.
It is recommended here that in order to grow the MOT programs one must take the proper use of these new information and telecommunication technologies and must increase the distance learning programs. This change will move us into the global arena and we will compete internationally for students.

4. IMPORTANT ISSUES AND THEMES IN MOT PROGRAMS

4.1 Themes in MOT Education

4.1.1 Business and Management Schools

The Business and Management schools are using a wide variety of themes and titles in their different MOT programs. The most common title is Entrepreneurship / New venture creation / Entrepreneurial studies of which the frequency noted is 108. Technology Management or Management of Technology (MOT) is another common theme of which the frequency noted is (39). Followed by the Innovation / innovation and change / Innovation studies (34), Innovation management / Management of Innovation (29), New product development (NPD) (28), Strategic management of technology (27) and Strategic Management of Innovation and Technology (20).

4.1.2 Engineering Management Schools

All these technological developments have started not only to change our ways of doing business, or managing our businesses but also there is an increasing demand for specially trained engineers and managers to manage the technological assets of many engineering companies.
(Arnold Reisman, 1994) argued that, *" In academic circles, engineering and technology management has or it is taking on the aura of a professional discipline"*.

Responding to this trend many engineering schools are also providing MOT programs. When looking at the most important themes emphasized in MOT programs by the engineering schools, it is observed that "Entrepreneurship/venture creation" is most frequently noted theme. The others are "Technology management/management of Technology" (12), "Innovation/innovation and change" (10), "Innovation management / Management of Innovation" (11) and "Strategic management of technology" (10) the most frequently noted themes.

Both the businesses as well as engineering schools are providing the Entrepreneurship studies with their different MOT program emphasis. Entrepreneurial studies seem to an emerging area in the MOT schools. The some of the MOT programs are providing a balanced technological and managerial focus also. Traditionally, being housed in either an engineering or business school, MOT programs have tended to be either technology oriented or business oriented.

One of the respondents in (Satish, N. and David, W. 2003) study argued that, *"we have been sending our engineering officers to MOT programs for some time now. However, while, at the detail level, they may have acquired specific business expertise (e.g. analytical techniques, vocabulary), there has been no appreciable change in their overall ability to adopt a business perspective while dealing with various technology issues. I am afraid most MOT programs still do not emphasize the need for their students to make such a mind shift."*
Reflecting the above issue, strategic technology management / Strategic management of technology or Strategic management of Innovation and Technology has become a strong theme of most MOT programs. Given that organizations are required to take decisions about technology more and more at the strategic level, such a perspective is valuable and timely in MOT curriculum.
It is very interesting to note that the engineering schools are less emphasis on engineering and manufacturing, and more on innovation management or project management. As it is observed that the engineering schools are offering innovation management theme (16%) more than offered by the business and management schools in their different MOT programs, innovations in general as (15%) while new product development (4%).

In addition of the above discussed themes, it is also identified that, a large number of research projects concerning with MOT are also being conducting in the different MOT schools through out the world. Some of the research areas in which MOT faculty and graduate students have been engaged for the last five years are analytic hierarchy process, cellular manufacturing, data envelopment analysis, disruptive technologies, E-Business, entrepreneurship, environmental management, gender and technology, innovation management, international technology management, IP management in high tech companies, productivity and quality management, R&D management, science and technology commercialization, strategic repositioning of technology, supply chain management, technology assessment, technology diffusion, technology forecasting, technology intelligence, technology marketing, technology transfer, technology planning, technology policy, and technology road mapping.

4.2 Themes in MOT Research journals

In the past few decades, this important issue how to manage technology has not only attracted the practitioners but also the academic researchers, the technology management community has developed a wide range of methodologies and applications for both academic research and practical applications. In this sub-section, I shall look at the different themes in technology and engineering management research journals in order to explore the recent and emerging trends in MOT research area.
This survey is based on a search for the different keyword index like, 'technology management', "Entrepreneurship", "New Product development" etc on

the Elsevier SDOS online database, this survey is also divided into the two broad categories (Business & Management and Engineering) and in this survey all the world best business, management and engineering journals are included. This search is divided into two parts in the first section the journals from 1995-1999 are included and in the other part the journals from 2000-to date are included.

The reason for choosing this period is that the Internet was opened to general users in 1994 and this new era of information and communication technology has played an important role not only in electronic commerce, but also in technology management.

It is identified that entrepreneurship is an emerging theme in the business management research journals during the last decade and its frequency is being increased from 19 in (1995 to 1999) to 98 in (2000 to date). It is surprisingly to observe that while entrepreneurial studies are increasing in MOT field but there is no any single number noted in the engineering management research journals during the last decade. This lack of focus on technology entrepreneurship in the engineering management research journals is surprising. So, this is included in one of the recommendations that to emphasize on the importance of technology entrepreneurship in engineering and technology management research journals and omission of this issue would be a serious threat for the future.

The other most frequent observed theme in the business and management research journals is New Product Development, which is increasing from a frequency of 14 to in (1995 to 1999) to 52 in (2000 to date). It is increasing as well in the engineering management research journals from a frequency of 06 to in (1995 to 1999) to 09 in (2000 to date).

There is a less number of increase in technology management area, which is increasing from a frequency of 30 in (1995-1999) to only 37 in (2000 to date) in business and management research journals and in the engineering management journals it is slightly increasing from 13 in (1995-1999) to 16 (2000 to date).

There is a dynamic increase in the theme Knowledge management, which is from 13 in (1995-1999) to 118 in (2000-to date) in the business and management research journals.

In the engineering management journal a small increment is also observed in the Total Quality Management, which is from 8 in (1995 to 1999) to 20 in (2000 to date).

There is also a decrease in the number of frequencies in some of the areas observed in both business management as well as engineering management research journals.

For example: The theme Total Quality Management in the business management research journals is decreasing from 28 in (1995 to 1999) to 15 in (2000 to date). Technology and Information Management is decreasing from 19 in (1995 to 1999) to 02 in (2000 to date).

In the engineering management research journals there is a decrease in project management theme, which is decreasing from 27 in (1995 to 1999) to 24 in (2000 to date). Continuous improvement theme is also decreasing from 9 to 3 and technology development from 9 to 2.

All the MOT schools are providing a broad spectrum of courses and themes, which are industry focus as well. Traditionally, being housed in either an engineering or business school, MOT programs have tended to be either technology oriented or business oriented. While MOT education focuses more on management than on technology, it emphasizes several MOT-related themes, which are innovation management, technology strategy as well as management, and new product development. Both the businesses as well as engineering schools are providing the entrepreneurship studies with their different MOT program emphasis. In addition to the MOT schools this field has also attracted the academic researchers. There are many trends, which are observed in the MOT research journals. Knowledge management seems to an emerging area in the MOT research journals. On the other hand, there is a lack of focus on knowledge management in the MOT schools. Entrepreneurship studies are also an emerging area in the MOT business and management research journals. The next section will discuss some common and some different trends in the MOT education and research in details followed by the conclusions of the study.

5. DISCUSSIONS AND CONCLUSIONS

The MOT field is emerging as a teaching as well as a research discipline during the last four decades. There are many communication systems available for the scholars as well as educators in this field. In the above section, I have identified the different trends in MOT education and in MOT research. From these trends some are common trends, which are providing by both the MOT research as well as teaching and some are different trends, which are either by providing the MOT schools or the MOT research journals. In the following pages, I will discuss in more details on these common as well as different, most likely why the differences are and what the implications should be?

5.1 Common trends in MOT schools and research journals

There are some common trends, which are providing by the MOT schools as well as MOT research journals.

Entrepreneurship: All the MOT schools are providing a large number of courses on entrepreneurship / entrepreneur studies / Technology entrepreneurship in their different MOT programs. Many of the business and management research journals are also emphasizing on this area. This is in response that entrepreneurial orientation has become crucial for organizations to flourish in most technological fields (e.g. computer industry, electronics, telecommunications industry), and educating future technology managers on how to encourage, develop, and manage such entrepreneurial activities. Indeed, it is the technological entrepreneurs and their teams who have brought forward so many innovations in communications, electronics, software,

and computing. Most MOT programs believe that it is sufficient to include one or two courses (on entrepreneurship), however, many think that they need to incorporate the key ideas in each and every course, so to achieve this goal they are providing entrepreneurship as an MOT program theme.
But it is surprisingly to observe that there is no any single number noted in the engineering management research journals during the last decade. This lack of focus on technology entrepreneurship in the engineering management research journals is surprising. So, it is recommended that to emphasize on the importance of technology entrepreneurship in engineering and technology management research journals and omission of this issue would be a serious threat for the future.

New Product Development: In today's dynamic marketplace where the companies are under intense pressure to introduce new products and services to keep up with their competition alive. In addition, new products are becoming obsolete in a very short period of time (e.g., computer products, electronic products, etc). Increased competition and reduced product life cycles mean that companies need to develop new products and services faster. This escalation of new product and new service introduction has promoted interest in research and pedagogy of the new product development process (Rao, V. R. 1997). Responding to this trend it is identified that new product development is being offered in both MOT schools as well as MOT research journals.

5.2 Different trends in MOT schools and research journals

There are some different trends also noted in the MOT education and research.

Knowledge Management: Knowledge Management is the themes of which a high number of frequencies are noted in MOT research journals and a very less number of schools are identified which are providing knowledge management courses in their different MOT programs.
Today, the competition is becoming more knowledge-based and that the sources of competitive advantages are shifting to intellectual capabilities away from physical assets. The increase in Knowledge management is because of this new era of information and communication technologies, because these technologies have plays a very important role not only in e-commerce but also in knowledge management (Liao, S. H. 2003). The creation of knowledge is important, the conversion of this knowledge into new products and services comprise the foundation of superior performance.
(Revilla, E., Sarkis, J., Acosta, J., 2004) argued that Knowledge management is still a relatively new area of teaching and thus consensus terms are still being formed like corporate intelligence, memory, learning, information, and data, are all part of this knowledge management scheme. Reflecting the above facts it is recommended to emphasize on the importance of knowledge management in the MOT education & training and omission of this issue would be a serious threat for the future.

E-Commerce: A high number of frequencies of this theme are noted in MOT research journals than in the MOT schools. The dramatic impacts of new technologies are opening the new delivery channels for consumer goods and services. One may argue that e-commerce is more related to the information technology area than the MOT. Many schools are providing e-commerce in their different IT related programs and only a few schools are providing e-commerce in their MOT programs. For example: In USA Georgia Tech University is offering e-commerce as an optional course in MOT as well as information technology management area.

Risk Management: A high number of frequencies of this theme are noted in business management as well as in engineering management research journals than in MOT schools. One may argue that as risk management is a broader field and as in this study all the business management and engineering management research journals are included, so a high number of frequencies may have been achieved. This is true in one sense but some MOT schools are still providing a flavor of risk management in their different MOT programs for example: George Mason University USA is offering Risk Management and Financial Innovation as an option in their MBA program with concentration in MOT. SPRU (University of Sussex UK) is providing Management of Technological Risks as an option in MSc program in Technology and Innovation Management. As all the MOT schools are emphasizing on the entrepreneurial studies, which needs some management of risks like management of financial risks etc. Reflecting the above facts it is recommended that MOT schools should include one or two courses on risk management like; Technological risks, financial risks etc. in their MOT programs.

6. CONCLUSIONS

Over the past decade or so, technology has played an increasingly central role in products and services, organizations, as well as in all other aspects of the society. This has translated into a critical need for people who are trained in managing different types of technological assets in varied commercial and non-commercial contexts. Despite such a demand, trained technology managers continue to be a scare resource. As Dr Alan G. Merten, President of George Mason University and Chair of the National Committee on Workforce Needs in Technology, recently noted, *"we have a technology management shortage in this country, shortage of people who can manage people who are technologists"* (Techway, 2000).
The MOT education was established to address this demand. MOT education as well as research has continuously evolved and grown during the last four

decades. To do this, MOT educators are attempting to better serve their student's professional requirements and meet industry needs as well. The information age accelerates borderless activities resulting in increasing global competition and the evolution of important issues, such as, entrepreneurship, knowledge management and the strategic management of technology and innovation.

If we will move toward the future, how should MOT be positioned? Badawy suggested that management of technology is an integrative process, not a functional activity such as engineering management. It focuses on integrating the technology side of an enterprise (i.e. manufacturing, IT, R&D) with the business side (i.e. marketing, finance) proposing alternative models for MOT education (Badawy, 1998). Other researchers have addressed the problem of MOT education within MBA or engineering management programs. Gruver and Stamos point out that a number of business schools have taken a 'mix-and-stir' approach to addressing the prospective employers' changing needs, essentially adding or substituting specific courses as degree requirements for business-school students (Santo, 2001).

In that sense, this study recognizes the following key issues:

- MOT programs are still in the process of evolving as a professional, increasingly well-defined discipline. It needs to achieve its own clear position as distinguished from traditional MBA and engineering management programs.
- Regarding the method of MOT program offering there is a scarce of distance learning programs. As a full time education for many employees is not a practical option. There exists a dichotomy for many employees that their employers are often unwilling to give them time off from work to study, as a result of this many more people are looking for distance-learning courses.
- Society and businesses are increasingly moving into the information age where technology and human talents are more crucial for a firm's sustainable competitive advantage. MOT education should be able to help answer for such new demands; for example, by helping MOT students achieve a high level of competence in IT, E-Commerce, knowledge management, Risk management and technology & innovation management etc.
- All the MOT schools as well as MOT research journals are providing a broad spectrum of courses and themes of which some are common and some are different. The teachers as well as researchers of technology can learn from each other regarding ideas, trends, and important themes to help design and position their MOT programs.

This exploratory study attempted to address a few important issues related to the emerging trends both in MOT education as well as in MOT research journals, type of MOT programs. The findings from this study will serve as a benchmark for developing new technology management curricula as well as for improving existing technology management courses and programs.

From this study both academicians and practicing managers of technology can learn from each other regarding ideas, trends, and important themes to help design and position their MOT programs.

REFERENCES

Badawy, M. K., 1996, 'A New Paradigm for Understanding Management Technology: A Research Agenda for Technocologists', *International Journal of Technology Management*, Vol. 12 No. 5 and 6, PP 717-732.

Badawy, M. K., 1998, 'Technology management education: alternative models'. *California Management Review*, vol. 40, No. 4, pp. 94-116.

Financial times 2004, Global MBA ranking Available at: http://rankings.ft.com/rankings/mba/rankings.html available on 25-07-2004

Kocaoglu, D., F., 1994, 'Technology management: educational trends', *IEEE Transactions on Engineering Management*, Vol. 41, No. 4, PP: 347–349.

Kocaoglu, D. F., 2003, 'Educational trends in engineering and technology management (ETM), paper presented at Conference of Technology Management for Reshaping the World, PICMET '03, *Portland International Conference on Management of Engineering and Technology*, 20-24, July 2003 pp. 153- 159

Liao, S. H., 2003, 'Knowledge management technologies and applications-literature review from 1995-2002', *Expert systems with applications*, Vol. 25, Page: 155-164.

Mallick, D. N. and Chaudhury, A., 2000. Technology management education in MBA programs: a comparative study of knowledge and skill requirements, *Journal of Engineering and Technology Management*, Vol. 17 No. 2, pp. 153-173.

Mignogna, R. P. 2002. 'An historical perspective on management education in the technology era'. [Online] Available at http://www.temi.com/MoTEducationArticle.htm on 07/24/04.

Nambisan, S. and Wilemon, D., 2002. 'Graduate management of technology education: a global survey, critical issues and emerging trends', *International Journal of Technology Management*, Vol. 24, No. 1, pp. 106-120

National Research Council 1987, 'Management of Technology: The Hidden Competitive Advantage', National Academy Press

National Research Council (NRC), 1991, 'Research on the Management of Technology: Unleashing the Hidden Competitive Advantage', NRC, Washington D.C Commission on Engineering and Technical Systems.

Rao, V. R., 1997, 'Resources for research and pedagogy on new product development processes', *Journal of Marketing Research*, Vol. 34 No. (1), PP. 185–92.

Revilla, E., Sarkis, J., Acosta, J., 2004, 'Towards a knowledge management and learning taxonomy for research joint ventures', *Technovation*, Article in press, Available on line at www.sciencedirect.com on 21 July 2004.

Santo, B., 2001. 'Engineering education broadens scope beyond technology' [Online] available at
http://www.eetimes.com/salarysurvey/career/careerside4.html. On 06/12/04.

Satish, N. and David, W., 2003, 'A global study of graduate management of technology programs', *Technovation*, Vol. 23 PP. 949–962

Techway, 2000, what it's going to take: an interview with Alan G.Merten, Washington Techway, August 14, 2000. [Online] Available at http://techway.washtech.com/news/1—15/moretech/3026-1.html.

Ulhoi, J. P. (1992) 'Strategic Considerations in Technology Management', *Technology Analysis and Strategic Management*, Vol. 4, pp. 311-318.