A BODY OF KNOWLEDGE FOR MANAGEMENT OF TECHNOLOGY (MOT-BOK)

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Abstract

A management of technology body of knowledge (MOT-BOK) has been the subject of research for many years. In April 2011 it was discussed at the Twentieth International Conference on the Management of Technology, in Miami, USA. Since then the author of this paper has acted as academic coordinator of the project. A fundamental format was suggested which was distributed for preliminary evaluation. In 2012 the MOT-BOK was reviewed at the Twenty First International Conference on Management of Technology in Hsinchu, Taiwan. This process has now to be taken further. The purpose of the paper is to outline developments to date and to seek comment and consensus.

1. Introduction

During the *Twentieth International Conference on Management of Technology* held in Miami in April 2011, the structure of an MOT body of knowledge (MOT-BOK) was discussed several times.

Subsequently a draft was prepared and distributed for comment to individuals and organizations. (See Appendix 1 for organizations). Responses varied. One third of the organizations approached commented, mostly by e-mail. These responses were used to revise the structure.

In March 2012 the MOT-BOK was discussed at the *Twenty First International Conference on Management of Technology* held in Hsinchu, Taiwan. The present version, the fifth, is now presented for further evaluation and discussion.

We would appreciate a larger response rate, especially as we are aiming for a BOK that has broad acceptance. Voluntary association should be the guiding principle. Some of the organizations approached, especially those abroad, referred to cultural differences and were cautious about commenting. It is clear that special efforts will be needed to ensure a free exchange of ideas. The present article hopes to contribute to that purpose.

The next step will be to place this material in the care of the International Association for Management of Technology (IAMOT) and the associated Management of Technology Accreditation Board (MOTAB). The intention is to

publish the material on an appropriate website. This exposure will allow for ongoing revision as the MOT community gains experience of the BOK and engages in a process of continuous improvement.

2. The evolution of management of technology (MOT)

Most initiatives in (MOT) can be traced back to the mid-eighties and a key publication, *Management of Technology: The Hidden Competitive Advantage.* According to this source: "Management of technology links engineering, science, and management disciplines to plan, develop, and implement *technological* capabilities to shape and accomplish the strategic and operational objectives of an organization (Task Force on Management of Technology, 1987, p. 9).

The striking feature of this initiative is the diversity of backgrounds of the MOT community. Participants include engineers, corporate managers, economists, and S&T policymakers. To allow for this diversity the field initially described itself as "multi-disciplinary", with no strict unifying focus. An attitude of "creative diversity" prevailed. The report advised: "As described earlier, the knowledge base in MOT is fragmented and undeveloped. What is needed at this time is not overdefinition and restriction, but freedom" (Task Force on Management of Technology, 1987 p. 18).

In practice MOT is pursued in two organizational settings and at five levels. It is pursued within the government sector, where it is concerned with science and technology (S&T) policy. And it is pursued within the corporate sector, where it is used at four different levels. The five levels may be described as follows:

1. Government

    1.1 S&T policy level

2. Business organization

    2.1 Enterprise level
    2.2 Divisional level
    2.3 Sectional level
    2.4 Individual professional level - e.g., specialist scientists and engineers

Viewed in this way, there is an overlap between MOT and engineering management (EM). MOT strives to cover all five levels, while traditional EM seems to concentrate on levels 2.2 to 2.4. This is addressed more fully later.

Since the Task Force's report in 1987, the field of MOT grew and adapted to evolving needs. While many of the skills in MOT came from the different

backgrounds referred to, the MOT community developed an own and unique set as well. One example is a procedure, at the enterprise-level, for capturing technology-based innovation opportunities.

To reflect the increasingly unique character of MOT, the community looked anew at the definition of the field. In 2009 the International Association for Management of Technology (IAMOT), in consultation with colleagues from other MOT organizations, proposed the following formulation. “Management of technology is a specialized professional practice that harnesses technology-based innovation opportunities. It guides technological progress, assesses the potential of individual technologies and applies this potential to the benefit of business, society and the environment” (International Association for Management of Technology, 2008, p. 19.)

3. The emergence of an MOT-BOK

As the field of MOT evolved, the community sought to establish a body of knowledge to guide education and research. Its recent history is summarized in Figure 1 (based on Khalil, 2011).

Many root thoughts contributed to the process. (e.g., Badawy, 1996; Khalil, 1993; Hosni, 2003; Pelc, 2002; and Van Wyk, 1990, 2002), it has not been possible to picture them all. Figure 1 captures the most recent steps only.

Step 1 was the formulation of a Credo for MOT. This was dealt with during two working sessions at international conferences. *The Twelfth International Conference on Management of Technology* in Nancy France in 2003, and the 2003 *Portland International Conference on the Management of Engineering and Technology (PICMET),* Portland, Oregon. (Van Wyk, 2004a, pp. 84-89.) Step 2 was an internal study of the Educational Committee of IAMOT to explore the scope of a BOK (Walsh and Vasconcellos, 2006). Step 3 was a report by Technoscan® Centre to the said Educational Committee: *A Template for Graduate Programs in the Management of Technology* (MOT). (Van Wyk, 2004b.) Step 4 was the formulation of a widely acceptable definition of MOT in 2009 — referred to above. Step 5 involved a number of research initiatives aimed at producing a fundamental format for the BOK (including Khalil, T. and Yanez, M, 2005; Yanez and Khalil, 2007; Yanez, M., Khalil T.M. and Walsh, S.T., 2010; Khalil, 2011; Van Wyk, 2011, 2012; and Yanez, 2012).

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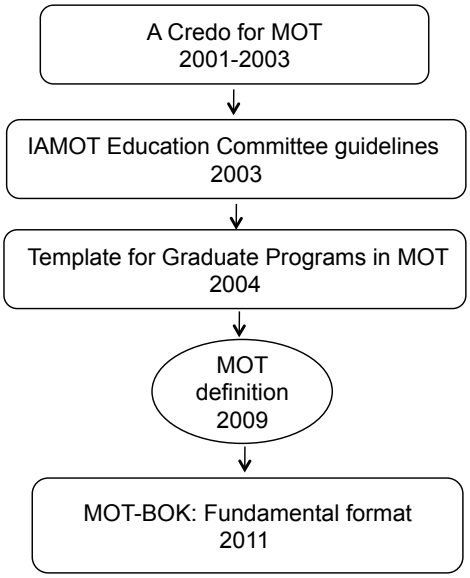

Figure1: Emergence of MOT-BOK

4. MOT-BOK: Fundamental format

While a high degree of agreement exists around the definition of MOT, there has been an ongoing debate about the future nature of the field. Two perspectives exist side by side:

- MOT should continue as a naturally *diversified* field of knowledge — in keeping with its original formulation. It should be left as a multi-disciplinary field with neither a unifying focus nor unique distinguishing features.
- MOT should be developed as a *unified* field of knowledge — In keeping with its pattern of evolution. It should have a unifying focus and unique distinguishing features.

The *diversified* perspective sees MOT embracing multiple academic disciplines. It accepts that many different phenomena all carry the name technology (approximately twenty), and it would acknowledge all of these. It favors a book of knowledge that pragmatically reflects the structure of the field as determined by the broad views of the MOT community. And it acknowledges a wide variety of technology-related managerial issues without identifying unique distinguishing features.

The *unified* perspective seeks to identify an academic discipline that can serve as anchoring point for the field. It favors reserving the label technology for one, single, phenomenon. Similarly it strives for one, generally agreed to, definition of MOT. It favors a book of knowledge rooted in a formal theoretical construct. And it would shape the field to meet unique demands of professional practice. In

particular it would emphasize skills not covered by other fields – notably the task of technology governance and of enterprise level MOT.

Ongoing debate shaped the format of the BOK. The debate is covered in the literature and is not repeated here. The proposed format, at this stage, is illustrated in Figure 2.

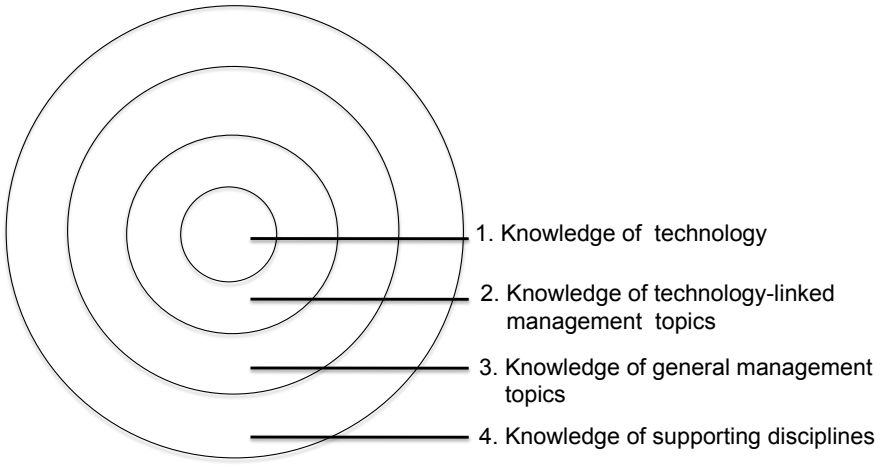

Figure 2: MOT-BOK: Basic format

This format distinguishes four knowledge areas:

- Knowledge of technology
- Knowledge of technology-linked management topics
- Knowledge of general management topics
- Knowledge of supporting disciplines

This format strives for a unified perspective without losing sight of the diversified constituents. The four areas of knowledge are discussed more fully below.

4.1 Knowledge of technology

This area deals with an understanding of technology as a phenomenon in its own right. Topics included in MOT programs are:

- Theory of technology
- Language of technology
- History of technology
- Atlas of technology
- Strategic technology analysis
- Emerging technologies

- Pivotal technologies
- Specialty fields

The centrality of “knowledge of technology” is a unique feature of MOT. It explores technological phenomena that are not covered in conventional branches of science, engineering, management, economics and S&T policy. In this respect it provides a missing piece in the knowledge needs of modern society — it focuses on the creation of common terminology for all technologies.

There is much potential for research and curriculum development in the area of knowledge of technology.

4.2 Knowledge of technology-linked management topics

This area draws on materials that are typically associated with high-tech companies, and that may be of limited interest to general management education. Topics include:

- S&T Policy
- Technology governance
- Technology-edified strategic planning
- Technology foresight
- Technology forecasting
- Innovation management
- Techno-entrepreneurship
- Technology auditing
- R&D Management
- New product management
- Project management
- Technology transfer
- Technology commercialization
- Intellectual property management

The area is partially served by home-grown MOT topics that feed on the first field, “knowledge of technology”. However it can draw on a wealth of topics developed within existing, dedicated, professional specialties like project management and innovation management. Some of these specialties have even developed their own BOKs.

This area usually contributes the greatest share of MOT programs.

4.3 Knowledge of general management topics

This area draws on knowledge typically rooted in general management degrees. It acknowledges the so-called functional classification of business activities, as

devised in the first quarter of the twentieth century. The functional classification provides the paradigm for most management programs in the world today.

- Strategy
- Marketing
- Operations
- Finance
- MIS
- HR
- Administration

This area is extremely well served by the MBA community. MOT can draw on extensive resources. Frequently MOT will teach the topics in a high-tech context, and sometimes offer innovations slightly outside of the mainstream management concerns. One example is “techno-finance” which deals with technology assessment for investment professionals.

Materials from this area are needed to ensure the status of a management qualification.

4.4 Knowledge of supporting disciplines

This area of knowledge acknowledges the multiple disciplines underpinning management in general, and MOT in particular.

- National policy frameworks
- General systems theory
- Economics
- Accounting
- Human behavior
- Quantitative methods
- Law
- Futures studies
- Industrial ecology
- Environmental studies

These topics vary significantly in their level of development. Some topics are well documented and supported by an extensive literature and even professional associations. Accounting would be an example. Others are in early stages of development, such as futures studies, industrial ecology, and environmental studies.

Major opportunities exist for fundamental research and curriculum development.

4.5 Program composition

MOT programs are populated with contributions from all four knowledge areas. Program directors choose a mix that reflects the particular focus of the school and the availability of resources.

A typical program could have the following suggested profile.

- Knowledge of technology — 20 percent
- Knowledge of technology-linked management topics — 40 percent
- Knowledge of general management topics — 25 percent
- Knowledge of supporting disciplines — 15 percent

In addition to the academic profile outlined above, most programs also include special assignments. These may be in the nature of:

- Research reports
- Capstone courses
- Business study missions
- Internships

The challenge is to maintain an overall common character while responding to diverse needs.

4.6 Status

At this stage there is a remarkably high level of consensus on the essential aspects of the BOK. Virtually all commentators favor the unified approach.

The basic format depicted in Figure 2 is generally accepted and has not drawn adverse comment. There have been many comments on the contents of the four knowledge fields. These comments have been accommodated as far as possible.

5. Guidelines for unresolved issues

There are two issues that are unresolved at this stage. They concern the definition of technology and the overlap between MOT and EM.

First, the definition. Which of the many phenomena that are all called technology is the subject matter of MOT? The need for clarity in this area is emphasized by recent texts outlining a deep dichotomy in the structure of technological knowledge.

- Knowledge of individual aspects is brilliant
- Knowledge of overall structure is non-existent

Arthur states the case most succinctly: “But we have no agreement on what the word ‘technology’ means, no overall theory of how technologies come into being, no deep understanding of what innovation consists of, and no theory of evolution for technology. Missing is a set of overall principles that would give the subject a logical structure, the sort of structure that would help fill these gaps.**”**

And later: “Missing, in other words, is a theory of technology — an ‘ology” of technology.” (2009, p.14.) When he comes to choosing a definition, Arthur resorts to three. Inevitably they are all different, but we do not pursue the matter further here.

Other authors confront the same issue. For example, in a recent anthology Li-Hua provides a useful overview of different definitions of technology (2009, pp. 18-22). The editors of the anthology come to the conclusion: “A single definition simply cannot fathom the complexity of technology in its entirety.” (Olsen, *et al.*, 2009, p. 3).

The paradox is that this issue had to be dealt with in the professional practice of MOT over the past thirty years. Professional practice simply could not proceed midst persistent uncertainty. Fundamental conceptual issues are part and parcel of Strategic Technology Analysis (STA), an area of MOT that dissects technology as a phenomenon in its own right.

After much deliberation the creators of STA chose a definition of technology that would identify and circumscribe technology as a distinct phenomenon that could be objectively analyzed and categorized. They defined technology as “*competence, created by people and manifested in devices, procedures and human skills”* (Van Wyk, 2004a, p. 23.)

This definition observes a number of conventions:

- The word “competence” implies an ability to execute. The definition therefore refers to the means of execution and not the ends. Final creations such as artistic expressions, literature and pure scientific insight are excluded.
- The word “created” indicates artificiality. To exist, technology has to be made by someone. It does not occur in nature. This definition therefore excludes natural phenomena such as silicon, DNA, and naturally occurring electricity. When these phenomena are deliberately altered to serve as means, the altered states fall within the ambit of technology.
- The word “people” limits our scope to human creators. We exclude devices, procedures and skills produced by animals. This does not

mean that the artifacts of animals, like the termite-gathering sticks of chimpanzees, the nests of birds and wasps, or spider webs, do not constitute some of the most technologically interesting devices on the planet. We do study them as a source of ideas. But we exclude them from the list of items for which we seek a formal collective structure.
- While human skill is included in the definition, humans as such are not.

Perhaps this definition, suggested in STA, could provide a guide for the MOT-BOK. It is important to note that this definition lays no claim to superiority. It simply states which technological phenomenon is regarded as the province of STA. It has gained acceptance within a small circle of experts, but it is not in widespread use beyond. In mainstream theory the concerns of Arthur and Li-Hua still call for resolution.

The second issue calling for clarification is the overlap between MOT and EM. This has been addressed by a number of authors. Alvear and co-authors offer a descriptive diagram showing the range of five areas of knowledge (Alvear et al., 2006, p. 1325):

- Public policy
- Corporate management
- Management of technology (MOT)
- Engineering management (EM)
- Engineering

Presented in this way the areas seem to range from “strategic” to “operational”. There is much overlap between MOT and EM, there are no clear lines of distinction.

Two sources of information offer some guidance as to the respective ranges of the two fields. First, the periodic surveys that the Portland International Center for the Management of Engineering and Technology (PICMET) undertakes of engineering and technology management (ETM) (Kocaoglu et al., 2003; Alvear et al. 2006). These cover the fields of EM and MOT combined. Although these surveys do not strictly distinguish between EM and MOT, the influence of the former, with a longer history, predominates. This history goes back to the 1940s (Pelc, 2002). The second source of information is a survey of the relative importance of the different constituents of MOT undertaken among the stakeholders of MOT (Yanez and Khalil, 2007). In this case MOT is more strictly defined,

The authors compare the nineteen “top-ranked disciplines” in the MOT-BOK survey, with the nineteen courses most commonly found in the curricula of 148 universities included in the ETM surveys (Yanez and Khalil, 2007, Table 3 et seq.). According to the authors:

"Six (6) out of the top 19 MOT BoK Framework disciplines were not among the 19 most commonly found courses in the ETM survey."

The missing disciplines were essentially concerned with the interface between technology and strategy. The authors conclude that: "This is the major distinguishing feature between MOT and Engineering Management and one which needs to be taken into account in the review and formulation of Management of Technology graduate level curricula."

In conclusion, two guidelines for a future BOK emerge. First, in the "Knowledge of technology" area — i.e., the central circle in the BOK — there is need for more intensive research and curriculum development. Second the activities that distinguish MOT from EM, and that "brand" MOT, are technology governance and enterprise level MOT.

For an MOT program to be an MOT program it should reflect these two guidelines.

6. Conclusion

With the publication of this article the task of initial academic coordination of the MOT-BOK will be completed. The topic will now be available for public scrutiny.

The MOT-BOK will be referred back to the International Association for Management of Technology (IAMOT), and the Management of Technology Accreditation Board (MOTAB), to be managed on an ongoing basis. It should be displayed on an appropriate website that allows for comment and refinement.

It is anticipated that IAMOT/MOTAB will also encourage research and curriculum development in knowledge areas where further effort would be beneficial.

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APPENDIX 1

ORGANIZATIONS RELATED TO MANAGEMENT OF TECHNOLOGY (MOT)

Academy of Management: Technology and Innovation Management division (AOM-TIM)

Association of Technology, Management and Applied Engineering (ATMAE)

Association of University Technology Managers (AUTM)

Canadian Association for Management of Technology (CANMOT)

China Association for Management of Technology (CAMOT)

Chinese Society for Management of Technology (CSMOT)

European Institute for Innovation and Technology Management (EITIM)

Industrial Research Institute (IRI)

Institute for Operations Research and the Management Sciences (INFORMS)

International Forum for Technology Management (IFTM)

International Society for Professional Innovation Management (ISPIM)

Portland International Center for the Management of Engineering and Technology Management (PICMET)

TechAmerica

Technology Management Education Association (TMEDA)

Technology Management Council (TMC) of IEEE

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