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TECHNOLOGY-CONVERSANT MANAGEMENT EDUCATION: INTRODUCING A NEW DISCIPLINE

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ABSTRACT

In the first quarter of 2013, the Department of Industrial Engineering at the University of Stellenbosch launched a new academic course, Strategic Technology Analysis (STA), as an elective in its M.Sc. in Engineering Management and M.Eng. Industrial Engineering degrees. STA views technology as a knowledge area in its own right, focuses on the inherent characteristics of technology, and explores its natural order. The purpose was to ascertain whether a course of this nature, which offered the outline for a new academic discipline, would be of benefit to a technology-conversant management programme. The course was well-received. It encouraged a greater awareness of technological positioning — i.e., aligning overall corporate strategy with new opportunities across the entire technological frontier. This article describes the background to this initiative, the history of STA, its inherent structure, and its role in professional practice. It then looks ahead at the possible dissemination of this knowledge into different settings where technology-conversant management is taught.

OPSOMMING

In die eerste kwartaal van 2013 het die Departement Berdyfsingenieurswese aan die Universiteit van Stellenbosch 'n nuwe akademiese module geloods, te wete Strategiese Tegnologie Analise (STA). Dit is as keusevak in die graad in M.Sc. in Ingenieursbestuur en M.Ing. in Bedryfsingenieurswese, aangebied. STA, beskou tegnologie as 'n kennisgebied in eie reg, konsentreer op die inherente eienskappe van tegnologie, en verken die natuurlike orde daarvan. Die leierskap van die Department wou vasstel of die plasing van so 'n module, in 'n leerplan vir ingenieurs- en tegnologiebestuur, akademiese voordele inhou. Die module was goed ontvang. Dit het bygedra tot groter insae in tegnologiese posisionering — d.w.s. die afstemming van ondernemingstrategie op nuwe geleenthede in die spektrum van tegnologieë. Hierdie artikel beskryf die agtergrond vir die besluit, die geskiedenis van STA, die onderliggende struktuur van die vak, en die gebruik daarvan in professionele praktyk. Daarna verken die artikel die verspreiding van hierdie kennis in verskeie opleidingsomgewings wat onderrig verskaf in tegnologies-kundige bestuur.

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1 INTRODUCTION

In the first quarter of 2013 the Industrial Engineering Department at the University of Stellenbosch launched a new academic course as an elective in the M.Sc. in Engineering Management and the M.Eng in Industrial Engineering degrees. The course was entitled Strategic Technology Analysis (STA). It viewed technology as a demarcated area of knowledge in its own right. The purpose was to ascertain whether a course of this nature, which offered the approach of an academic discipline, would be of benefit to a technology-conversant management programme.

The course was well-received. It enhanced the grasp of technology, and increased know-how for enterprise-level engineering and technology management (ETM). This included know-how for advanced tasks such as technological positioning — i.e., aligning corporate strategy with unfolding opportunities along the technological frontier.

This article describes the background for this decision, explores the history of STA, notes its composition, and describes its use in professional practice. It then looks ahead at the possible further development and dissemination of such an approach.

The Department of Industrial Engineering undertook this initiative in the light of an urgent global need for well-crafted programmes in technology-conversant management, and because it sought a greater level of technological cognisance and sophistication for its engineering alumni.

The truth is that, although technology is the major source of economic growth, it is not harnessed effectively enough. Most companies are not very good at technology-based, game-changing innovation. Many opportunities are missed. A large percentage of innovations fail. Billions of dollars are wasted each year on poor technological investments. Furthermore, unwise technological initiatives cause pollution that threatens the very life-giving forces of nature.

A special kind of knowledge is needed effectively to harness and manage the continually expanding technological universe.

2 BACKGROUND

Internationally there are many examples of technology-conversant management programmes, mostly at the graduate level. Dedicated programmes currently number around 300. Earlier data on the number of programmes shows an increase from 32 in 1976 to “over 160” in 2004 [1].

Some of the programmes are taught in engineering schools, and fall into the realm of engineering and technology management (ETM). Depending on where in the world they are taught, they typically earn an M.S. or M.Sc. in Engineering Management, or an M.Eng. degree. Some programmes are taught in dedicated centres, such as those for technological leadership, and earn degrees such as the Master of Science in the Management of Technology (MS-MOT). Some are taught in business schools and earn degrees such as an MBA in the Management of Technology.

In addition to programmes specifically dedicated to technology-conversant management, there are also clusters of courses that are taught as individual offerings in programmes with their own professional focus. These would include programmes in professional engineering, science and technology policy, innovation management, and development economics.

Across the world programmes are constantly being created, remade, or retired. The field displays erratic growth. One of the pioneering programmes, the Management of Technology Program at MIT, serves as an example. It was established in 1981 as a joint programme of

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the schools of management and engineering. Later it became the sole responsibility of the Sloan School of Management. At the turn of the century, after an independent existence of 20 years, and "realizing that the needs of technologists and entrepreneurs were fast merging with the needs of CEOs and general managers", the programme was merged with the MIT Sloan Fellows Program in Innovation and Global Leadership [2].

In certain centres there is a noticeable increase in academic research activity. So, for instance, the ETM programme at Portland State University recently graduated nine Ph.D. candidates — the largest number in the history of the institution.

Although the field has evolved academically over half a century, its institutional base remains relatively modest. Three international organisations are well established: the International Association for Management of Technology (IAMOT), the Portland International Center for the Management of Engineering and Technology (PICMET), and the Technology and Innovation Management (TIM) Division of the Academy of Management. At least ten other organisations can be identified that actively care for and promote the field. A tentative list is offered in the Appendix.

Within the last five years, MOT activities saw a major institutional innovation — the creation of a Management of Technology Accreditation Board (MOTAB) under the auspices of IAMOT.

3 TECHNOLOGICAL KNOWLEDGE

Surprisingly, the above developments all took place without the benefit of an established and generally accepted programme template. Consequently, every educational programme is different. Admittedly, there is a natural tendency towards pragmatic convergence; but, until a programme template is internationally agreed upon, directors have much freedom in crafting their own offerings.

It lies beyond the range of this article to delve too deeply into the best structure for a template. But two questions are relevant and of immediate concern. First, how much technological knowledge should be taught on the programme? And second, to what extent should research efforts address fundamental questions of technological knowledge?

In this respect, the preferences of programme directors differ widely. Surprisingly, some directors dispense with the need for explicit instruction in technological knowledge altogether. In practice they cover the need by means of undergraduate requirements. They ask that their candidates have appropriate undergraduate education in natural science, engineering, mathematics, or related fields. A second group sees technological knowledge as a key ingredient and gives it a high priority.

In the Department of Industrial Engineering at Stellenbosch, the preference is for the second point of view; hence the inclusion of STA. To understand this decision more fully, it is useful to trace the evolution of technology-conversant management education.

4 SHARPENING FOCUS

Many initiatives can be traced back to the mid-1980s and to 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" [3].

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

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described earlier, the knowledge base in MOT is fragmented and undeveloped. What is needed at this time is not overdefinition and restriction, but freedom" [4].

Given this freedom, the field evolved rapidly over the next three decades. Two perspectives emerged and exist side by side. According to these two perspectives, technology-conversant management programmes should either:

- Be left as multi-disciplinary activities — without emphasising a unique distinguishing competence; or
- Concentrate more on effective technology guidance — including technological positioning, i.e., technology-based game changing innovation.

The implications for programme design and teaching technological knowledge are far-reaching.

The first approach accepts the present somewhat loosely-structured state of technological knowledge. It acknowledges that many different phenomena all carry the name technology — of which there are approximately twenty. It also acknowledges a wide variety of technology-related managerial issues, and it favours a programme template that pragmatically reflects the composition of the field as determined by individual preferences.

The second approach seeks a far more organised state of technological knowledge. It favours the choice of one, single phenomenon to be described as technology. It favours a programme template rooted in a formally-recognised theoretical construct. And it seeks an academic discipline that can serve as a focal point. This does not mean that other disciplines should be excluded from the programme, only that a base-plate course should be created, around which other courses can be arranged.

5 AN ANCHORING DISCIPLINE

One of the questions that the second approach brings to the fore is the actual choice of an anchoring discipline.

In the late-1970s a circle of specialists in ETM, working in professional practice, actively pursued this question. The circle searched for a discipline in two directions:

- Within the range of technology topics
- Within the range of management topics

Within the range of *technology* topics the most attractive candidate was general systems theory (GST). This field provided a comprehensive view of systems in evolution, and saw a system as a unified totality while acknowledging the roles of individual components. It offered a contextual map for multiple technologies. However, it had a major disadvantage. In professional practice there was a widely-held perception that GST was too theoretical. It required mastering a set of concepts that were not consistent with the technical jargon of the workplace. It was difficult to convey to people not skilled in GST.

Within the range of *management* topics the ETM circle investigated the traditional business categories identified by Fayol: marketing, finance, production, human resources, administration, and general management. Production management offered some useful frameworks. But while they blended well with the many detailed topics in ETM, they were far too 'micro' for an overall perspective. Then the circle investigated the frameworks of corporate strategy, and particularly the template for scanning the macro-environment. It differentiated seven landscapes: nature, demography, society, technology, economy, institutions, and politics. Here there was a clear home for technological thinking. But in probing further, a sensitive void revealed itself.

Most of the landscapes had the benefit of dual perspectives: a 'micro' perspective that permitted a detailed view, and a macro-framework that gave an overall view. As it turned out, dual views existed for every landscape except technology. There was a dichotomy in technological knowledge.

The consequence was that strategic technology scanning – and the activities that derived from it –was a near impossibility. There was hardly any know-how to position overall corporate strategy so that it could harness new technological developments.

The circle concluded that what was needed was a new structure of technological knowledge. In addition to the many specialties for which there was brilliant knowledge, a macroscopic view was required to provide an integrated grasp of the entire field. The circle saw value in a field of knowledge that would treat technology as a discernible phenomenon in its own right, was based on the inherent characteristics of technology, and reflected its natural order. The circle saw a great practical benefit in a 'science of technology'.

The macroscopic structure would have to be expressed in terminology that was acceptable to technology experts, and at the same time understandable to practicing managers. Over the years, the circle formulated the rudiments of the required field. It drew on general systems theory, technology philosophy, and technology forecasting [5] [6] [7]. Participants published their findings in the international literature and applied their formats in professional practice [8] [9] [10] [11]. The field became known as Strategic Technology Analysis (STA).

STA found immediate application within the circle of specialists. It had adherents in the USA, Europe, South East Asia and South Africa. At the beginning of the 21st century it was regarded as a well-grounded area of knowledge — but only partially codified. It could be described as a coherent system of concepts and constructs, but it was not yet a rounded academic discipline. It had a long way to go to become a 'science of technology'.

To understand its essence, it is useful to examine its structure more fully.

6 THE ESSENCE OF STRATEGIC TECHNOLOGY ANALYSIS (STA)

6.1 Defining technology

The first matter that the circle had to resolve was the definition of technology. From the many phenomena that all carry the name 'technology', the creators of STA had to choose one particular phenomenon that reflected practical reality. In this respect they were guided by common usage rather than by epistemological dictates. Technology was neither merely about hardware and software, as is frequently implied, nor was it a coherent field of knowledge as dictated by its historical roots [12]. Common usage implied a certain kind of embodied ability.

This notion gave rise to the following definition: *Technology is competence, created by people and manifested in devices, procedures and human skills* [13].

This definition contains 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, such as 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 logical structure.
- While human skill is included in the definition, humans as such are not.

It is important to note that this definition lays no claim to superiority. It simply reflects one phenomenon out of many, all of which are labeled 'technology'. Having selected one definition, it was now possible to move forward and to explore an improved structure of technological knowledge.

6.2 Creating an integrative view

To probe further the essence of STA, we may use as reference the key features of an integrative view. Three are frequently found:

- A core characteristic present in each individual object being studied
- A format to describe individual objects
- A format to describe the assembly of all objects

This key is depicted in Figure 1.

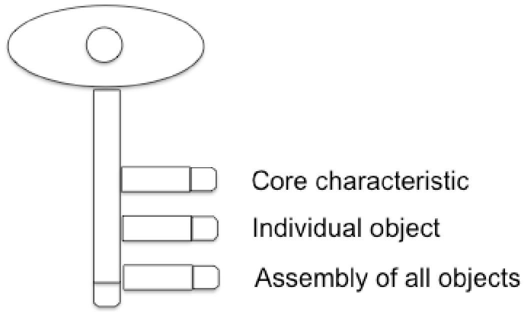

Figure 1: Key to an integrative view

The uses of the key may be illustrated by using the examples of botany and chemistry. In the case of botany, the *core characteristic* used in the description by Linnaeus is the reproductive organ of individual plants. The *individual object* is the plant itself. And the *assembly of all objects* is the botanical universe captured in the Linnaeus taxonomies. In the case of chemistry the *core characteristic* is the atomic number. The *individual object* is the chemical element. And the *assembly of all objects* is captured in the periodic table of the elements.

What should the profile look like for technology?

The most difficult step was the choice of the first constituent — the core characteristic. Technology consists of so many variables that no single one logically presents itself as the core characteristic. After much deliberation the circle settled on *functionality*.

There were five reasons for this decision. First, it was argued that the essence of technology is to provide functionality. Second, functionalities display a natural order in the physical universe. Third, because there are only a limited number of functional categories, the use of the notion could lead to profound simplicity. Fourth, functionality can be measured. Fifth, functionality was a concept used by professionals in both management and technology circles.

There are many discussions in the literature that probe the usefulness of ‘functional type’ for analytical and classification purposes. Two references illustrate the reach of the debate [14] [15]. These discussions range much further afield than the issues covered in this article, and so are not pursued further here. Generally speaking, they corroborate the usefulness of the notion of functionality, which we examine more fully in the next section.

The second constituent, the format for analysing individual objects, also proved problematical. What is the unit of analysis in the case of technology? In conventional jargon: what phenomenon served as the ‘carrier’ of technology? Common use had not settled on a generally accepted unit. The creators of STA searched in vain for the equivalent in technology of the biological entity ‘organism’.

Flowing from the definition of technology, the idea arose of a composite unit consisting of device, procedure and human skill — or, to put it differently, hardware, software, and skillware. Units such as these exist in reality. They were a convenient choice for structuring technological knowledge.

The third constituent was a format to analyse the assembly of all objects, the techno-sphere. Again this was not a concept in common use. In fact, the creators of STA were quite surprised that no field of knowledge studied the techno-sphere – i.e., the technological universe. In terms of our earlier examples: the ‘phyto-sphere’ in the case of botany, and the ‘chemo-sphere’ in the case of chemistry, were served by excellent taxonomies. This was not the case for the techno-sphere. And STA never mastered a complete technological taxonomy.

At best STA achieved an elegant formulation of a technological conspectus — a concise overview based on a unifying theory. In this respect it is convenient to visualise the layers of technological entities as they populate the globe. They occupy four domains: subsurface, surface, near space, and outer space. This is discussed further below. For analytical purposes further categorisations were explored. But it would take us too far afield to present these in detail.

For STA it was possible to match the three constituents together — as far as they had been developed at that stage. A coherent system was formed that cast technological knowledge in a new, more integrated, structure.

6.3 The descriptive power of ‘functionality’

The new structure of technological knowledge that had been created depended heavily on the notion of *functionality*. This notion imparts a natural order to the field, an order that emerges from the following line of reasoning.

Functionality may be seen as the ability to perform given tasks. In the case of technology, it is the ability to transform physical reality and to improve social utility. Transformation occurs through three basic actions:

- Process, which involves changing inputs into new forms of outputs
- Transport, which involves moving inputs physically into new locations
- Store, which involves holding inputs for a period of time before releasing them later as outputs in another time period

The outputs of transformation are the various parts of physical reality. In the most concise formulation, there are three:

- Matter (M)
- Energy (E)
- Information (I)

This threefold distinction was formulated in the middle of the 20th century. Before that time only the first two parts were popularly used. The addition of the third required a bold assertion. In 1948 Norbert Wiener declared: “Information is information, not matter or energy. *No* materialism which does *not* admit this can survive at the present day” [16].

This assertion sparked a debate within the scientific community. Some members, to be called the M-E school, confined physical reality to the first two constituents. Other members, the M-E-I school, included all three. In time the balance seemed to shift in favour of the latter.

Almost forty years after Wiener's assertion, scholars came to the conclusion: “Evidently nature can no longer be seen as matter and energy alone. Nor can all her secrets be unlocked with the keys of chemistry and physics, brilliantly successful as these two branches of science have been in our century.” Further: “A third component is needed for any explanation of the world that claims to be complete. To the powerful theories of chemistry and physics must be added a late arrival: a theory of information.” And finally: “Nature must be interpreted as matter, energy, and information” [17].

By combining the three parts of physical reality with the actions defined above, *nine fundamental categories* of functionality emerge. They are:

- Process:
  1. Matter (M) – e.g. make steel
  2. Energy (E) – e.g. generate electricity
  3. Information (I) – e.g. calculate mathematical formula
- Transport:
  4. Matter (M) – e.g. send by rail
  5. Energy (E) – e.g. transmit through the grid
  6. Information (I) – e.g. display on e-book
- Store:
  7. Matter (M) – e.g. stockpile ingots
  8. Energy (E) – e.g. charge batteries
  9. Information (I) – e.g. backup on hard disc

6.4 The functionality grid

The above, profoundly simple, categorisation allows the range of functionalities to be organised into a matrix format that has become known as the *functionality grid*. It is illustrated in Figure 2.

The functionality grid was inspired by the original formulation of Ropohl [6]. It has had a defining influence on the field of technology-conversant management, and can be thought of as a basic format for STA.

The grid provides the format for a technological conspectus as needed in many practical applications. It can serve as a micro-format to dissect a particular technological entity. It can also serve as a macro-format to obtain overviews of the techno-sphere. The important thing is that these formats are not informal pragmatic gatherings of individual phenomena: they are based on a unifying order that links the individual entries in a coherent whole.

Inevitably the grid has attracted the attention of academic researchers seeking to unlock its subtle analytical powers further. For example, a recent Ph.D. study probed the viability of the grid as a possible paradigm for the whole of MOT [18].

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		Output		
		Matter (M)	Energy (E)	Information (I)
Action	Process			
	Transport			
	Store			

Figure 2: The functionality grid

7 THE IMPACT OF STA

7.1 Academia and professional practice

While STA is still a developing area of knowledge, it has found application in a number of academic courses. Internet searches yield some examples of these. One example, from the early 1990s, is the use of STA as an introductory course in an academic programme in management of technology — the MS-MOT programme of the Center for the Development of Technological Leadership (later renamed the Technology Leadership Institute), University of Minnesota.

In executive education STA has established a solid track record. It has been offered in-house to corporate clients, and has been hosted successfully by universities and professional organisations. Corporate clients included companies in space services, chemicals, textiles, forestry, diamond mining, electronics, sensors, mobile phone networks, instrumentation, and retailing. Professional organisations included the International Association for Management of Technology (IAMOT), Portland International Center for Management of Engineering and Technology (PICMET), and the International Forum on Technology Management (IFTM).

Frequently in-house seminars were used to launch consulting initiatives in technological positioning — as referred to above. This is probably the most significant application of STA. Because of confidentiality agreements, these initiatives have not been published academically.

7.2 Mainstream literature

While STA flourished within a small circle of adherents, it has not yet had an explicit impact on mainstream technological knowledge.

To understand the present status of this knowledge, it is useful to refer to three recent texts. The first is an anthology reviewing the status quo; the second identifies serious shortcomings; and the third offers a creative solution.

The first text, published in 2009 and referenced below, gathers the views of 79 authors in *A Companion to the Philosophy of Technology*. The book cover describes the text as the "first comprehensive authoritative reference source for this burgeoning and increasingly important field". The variety of views expressed by the authors illustrates the rich diversity. It leaves an overwhelming impression of the absence of any unifying order. This impression is well exemplified by Li-Hua in his review of the "Definitions of technology" — the use of the plural is significant [19]. The editors of the companion then come to the conclusion: "A single definition simply cannot fathom the complexity of technology in its entirety" [20].

The second text, by Arthur and also published in 2009, is entitled *The Nature of Technology*. It is far more direct in its critique of the status quo. "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." He concludes: "Missing, in other words, is a theory of technology — an 'ology' of technology" [21]. To move matters forward he suggests mapping out the ecology of technology within an evolutionary framework.

The third text, by Kelly and published in 2010, is entitled *What Technology Wants* [22]. It points to the need to understand the technological totality, and suggests a unique concept for this phenomenon — the technium. This is a most creative concept, and Kelly offers a penetrating analysis. He emphasises the inner directedness of the technium. He describes its evolutionary path, and characterises it as a kingdom of nature. There are many parallels between the notion of the technium and the notions of the techno-sphere and the technological universe.

All three of the above texts dovetail with the ideas that prompted the creation of STA. But as far as mainstream literature is concerned, no effective carry-over is recorded. The same areas of incomplete technological knowledge that were noted 30 years ago are still in evidence in the first decade of the 21st century. Technological knowledge still suffers from the already-mentioned deep dichotomy: diversified knowledge of individual specialties is brilliant, but integrative knowledge that binds them together is absent.

8 RECENT STEPS

In 2012 it was decided to launch a special initiative to increase awareness of the unifying order that marks the essence of STA. It was decided on a wide-ranging initiative that would include all communities involved in technology-conversant management. This initiative required a far greater academic effort than had been conducted in the past. It also needed an intellectual setting with a society-wide and international outlook.

An approach was made to an independent think-tank, the Stellenbosch Institute for Advanced Study (STIAS), to become involved in such an initiative. In 2012 the STIAS Fellowship and Programme Committee supported this involvement. It created a fellowship to address a project. Its purpose was to "improve the structure of technological knowledge and simplify the language of technology".

The project involved a period of tenure at the Wallenberg Research Centre in Stellenbosch, a series of academic meetings with STIAS Fellows, and a seminar to report outcome. One of the most startling revelations that emerged during the research was the low level of concern for technological matters that was noticeable throughout society. Certainly there was interest in the details of specific technologies, but the general level of cognisance of how these interacted at a macro-level was remarkably restrained. This applied not only to non-technical individuals, but also to technology experts. Technological knowledge was afflicted by a deep dichotomy that attracted hardly any academic interest. This is a danger signal of enormous intensity, requiring inspired remedial action.

The output of the STIAS project was an academic guide: *Technological knowledge — A new structure* [23]. It moved STA closer to the status of a 'science of technology', but crucial work remained to be done. Progress was reported in a series of presentations to the Stellenbosch academic community.

It was within this atmosphere that the Department of Industrial Engineering chose to include a new course, based on a focusing discipline, in its academic programmes. As described in the Introduction, this occurred in the first quarter of 2013. STA met two requirements: first, it offered an elegant way of including technological knowledge in a technology-conversant management programme; and second, it established a unique disciplinary anchor based on a new structure of technological knowledge.

The new course used the guide already referred to as its academic text [23]. The course was taught as a 32-hour elective. Its pioneering nature was emphasised, and the potential for research noted. The research requirement called for a report of about 10,000 words. Participants were encouraged to focus their research on structured technology foresight.

9 LOOKING AHEAD

As pointed out, there is much scope to improve the social cognisance of technological matters. There is a clear need to disseminate the improved structure of technological knowledge as widely as possible, and to encourage research to ensure theoretical compatibility and practical utility. There is a vast potential for resuscitating the science of technology as a full academic discipline.

Against this background, the Department of Industrial Engineering is exploring the development of STA as a proto-type for further dissemination. The first initiatives are aimed at ETM programmes located close to one another.
The second initiative is to enlarge the target for course participants in STA by admitting executives from professional practice, who would earn a recognised certificate of competence.

In addition to the benefits that STA could hold for programmes in ETM, benefits could accrue to technology-conversant management programmes in adjoining professions. Some communities that would benefit are illustrated in Figure 3.

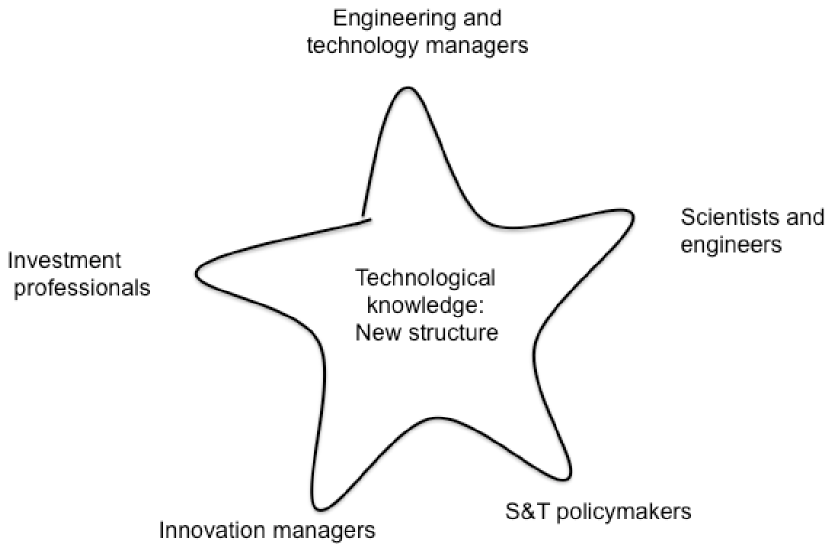

Figure 3: Communities to benefit from a new structure of technological knowledge

There is a golden opportunity for ETM professionals to shape technological thinking and to make technology easier to grasp, to guide, and to communicate. This will enhance not only the status of the profession, but allow it to be a defining influence for the wiser utilisation of technological opportunities. The further dissemination of the new structure in technological knowledge would contribute to an improvement in the quality of life throughout the world.

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APPENDIX

PARTIAL LIST OF ORGANISATIONS RELATED TO ETM

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)

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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