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The knowledge of organisations and the organisation of knowledge

A post-industrial society?

Over the last 25 years or so the prosperity of countries in North America, the European Union, and perhaps to a lesser extent the prosperity of Japan, has relied less and less on heavy industry and more and more on information, services and research. Newspaper commentators have been predicting the demise of heavy industry for more than half a century. Now, the post (heavy-) industrial age is upon us: politicians and pundits of various hues are talking about foundations for a post-industrial future. The harbingers of this future are new words, or neologisms, like information superhighways, infobahns, the wired society, knowledge societies and knowledge-based economies.

Major industrial cities such as Detroit, Sheffield and Yokohama, once strategically important, are now regarded as 'rust belts' and instead we have various silicon-geographical features, such as Silicon Valley near San Francisco and, in the UK, Silicon Fen near Cambridge and the Silicon Corridor in Berkshire. The arrival of scientists and engineers in valleys, fens and corridors signals a transition from the industrial to a post-industrial society. The emergence of this society has been accompanied by discussions about organisational knowledge and organisational learning. The terms 'organisation', 'knowledge' and 'learning' are broad and ambiguous, but this has not deterred the post-industrial thinkers – especially the leading management experts and others – from talking about methods, tools and techniques that will improve organisational knowledge and learning.

The post-industrial society has in some sense succeeded the post-modern society. During their heyday in the 1930s, the post-modernist vanguard challenged the traditions and conventions of what is referred to as the 'modern' society (c.1900s). The modernists were largely sustained by and thrived upon the fruits of the industrial revolution. The post-modernist challenge spread from literary and cultural mores of the times to embrace economic, social, political and management norms and wisdom.

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According to management guru Peter Drucker, it was only at the beginning of the 20th century (c.1895–1905) that *management* was distinguished from *ownership* in Germany: Georg Siemens, a leading banker of his time, asked Werner Siemens to hand over control of the latter's near-bankrupt electrical engineering enterprise to professional managers. Soon afterwards, Andrew Carnegie and John D. Rockefeller followed suit in the USA. The period 1895–1905 coincides with the rise of the modernist movement; the post-modernist equivalent in the industrial genesis of the Northern Hemisphere was the period 1920–1950. This genesis saw command-and-control structures introduced by the chemical giant du Pont, by General Motors – one of the pioneers of automotive engineering – and by the engineering colossus General Electric. Hierarchically organised enterprises emerged during this period, coinciding with the ascent of post-modernism in the arts, literature, music and politics.

New wisdom

The post-industrial society has emerged in a climate where multinationals move the design and manufacture of goods around the globe with the deftness of ballet artists. The conventional wisdom of the post-modern age, that of mass production and well-stocked warehouses, has given way to technologies with idiosyncratic names: just-in-time or kan-ban, lean manufacturing, business process re-engineering, and finally to the curious neologism 'knowledge management' in the mid-1990s. Knowledge management is the term used to articulate the concept that knowledge is an asset on a par with the tangible assets of any organisation – land, capital, plant and machinery. Management involves the management of assets, *ergo* knowledge should be managed from its inception through its nurturing to maturity to exploitation and to ultimate obsolescence. Knowledge may be considered intangible yet it has a lifecycle: conception–birth–maturity–death.

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The post-industrial age emphasises the role of change and the ability of organisations to adapt themselves to changing circumstances. This change may lead to different products or services and to different competitors at different times and in different places. Post-industrial organisations are more design-aware and in some sense maintain a dialogue with their customers. The post-industrial society differs from the post-modern society in a number of ways: the structure of a post-industrial organisation is generally dynamic whereas the structure of post-modern organisations was static; consumer needs in a post-modern society were regarded as stable whereas the post-industrialist regards them as constantly changing. The table compares and contrasts the two types of organisation.

The American Daniel Bell and the Frenchman Alan Touraine coined the term 'post-industrial' independently on either side of the Atlantic. Touraine's book *The post-industrial society* (1970) was followed by Bell's more evangelical title *The coming of post-industrial society* (1973). Bell's 'expert class' and Touraine's 'highly skilled technicians' are expected to play the same pivotal role in the post-industrial revolution as did the old working class during the October Revolution in Russia. Bell's definition of the expert class comprises the old-denomination middle class, some of whose members work in the laboratories at the MIT, Stanford and at Oxbridge colleges, for instance. Touraine's heroes and heroines are the old-denomination skilled working class people with aspirations.

The engineering profession in the UK pioneered knowledge management through the establishment of the various engineering institutions (civil, electrical, mechanical, and so on) over 100 years ago. These institutions are involved in knowledge dissemination and in the accreditation of knowledge acquired by engineers at work. The institutions in some sense managed the knowledge of their specialisms for and on behalf of their members. The engineering employers were interested in how their employees created new products and services and also in new forms of organisational structure. It is not clear, however, to what extent the employers were directly involved in the creation of new knowledge. The appointment of 'knowledge officers' in applied research organisations like DERA shows an interest in proactively conserving and creating knowledge.

The management of expert knowledge is a key factor in sustaining the socio-economic order of the post-

The key differences between post-modern and post-industrial organisations.

	Post-modern organisation	Post-industrial organisation
Structure	Passive, static	Interactive, dynamic
Products	Durable, dull	Disposable, stylish
Consumer needs	Stable	Constantly changing
Markets	Geographically well-defined	Fuzzily defined boundaries
Competition	Identifiable rivals: 'war of position'	Changing rivals: 'war of movement'

industrial age, much in the way that material capital was key in sustaining order in the post-modern age. This knowledge capital has to be constantly renewed and supported by the equivalent of the financial institutions that help to renew and support the needs of society as far as material capital is concerned. Academia, the engineering institutions, the Royal Society, the state-funded and privately funded Research Councils and the various training organisations may be involved in 'financing' the knowledge capital needs of societies. These organisations are reflective in nature and sometimes slow to respond: perhaps mechanisms should be put in place to expedite their decision-making processes. But then again these institutions may be purely driven by curiosity and may have no deep desire to contribute directly to knowledge-creating activities for society at large. So we should keep a serious watch on the recent phenomena of venture capitalism, business angels, start-ups and spin-offs, and virtual universities. These are grand vistas and I would keep away from these exciting and volatile phenomena and concentrate on something tangible.

The professionals, knowledge officers, experts and skilled technicians all have one thing in common: they all use sign systems comprising written and spoken language, graphics, pictures and notation to communicate with others. The use of these signs facilitates our ability to criticise existing knowledge and create new knowledge and here the role of language, primarily written texts, is most apparent. But more of this later.

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New traditions

The revolutionaries who heralded the post-industrial society, like their forebears who heralded post-modernism, have been busy with their list of new terms. 'Just-in-time' technologies are intended to stop the confusion and obfuscation usually attributed to warehouse managers; the 'outsourced' component delivery organisation now has to have a telepathic anticipation of the needs of the factory floor. 'Lean manufacturing' is to be the panacea for all the wastage of flabby manufacturing. And so to a whole new terminology comprising the term 'knowledge' as a prefix. At the beginning of this article I remarked that 'knowledge' is a broad and rather ambiguous term. Standard dictionaries of philosophy suggest that knowledge confirms belief or, sometimes, displaces it. The reader will perhaps need to exercise some caution when dealing with terms that contain 'knowledge' or other equally ambiguous terms like learning and organisation.

Peter Drucker introduced the terms 'knowledge work' and 'knowledge worker' in the 1960s. The term 'knowledge management' refers to the management of the knowledge of the knowledge workers. The knowledge workers, their managers, the owners of the enterprises and the customers of the goods, services and information produced by the enterprises, are interdependent. It has been claimed that these 'players', in their interactions, develop cultural edifices and a kind of a society: the 'knowledge society'. This society, like others, demands a system of recruitment and values and their transmission from one generation to the next, and some means of enforcement and discipline. The implication of the term 'knowledge society' is that there may be times when society will expect individuals to subordinate their interests, and sometimes perhaps their existence, to what may be perceived by the more persuasive members of the community to be in the wider society's best interests. The management of expertise, the key asset of the knowledge worker, appears to be the central concern amongst those who have reservations about the whole enterprise of the knowledge society.

It is true – if one considers the sheer number of people throughout the world who partake of higher education and the lesser, yet perhaps equally significant number involved in research and development – that the 20th century heralded mass education. The scientific methods and technological innovation protocols of the 20th century affect humanity on a global scale. There is the truly liberating impact of mass communication and telephony. We live in a global village where scientific discoveries are sometimes reported with the same speed and exuberance as news is reported of political change and economic up- and down-turns. In contrast, scientists are also held responsible (rightly or wrongly) for nuclear waste, global warming, and so on.

One can argue that the foundations for a post-industrial society were being prepared by an ever-increasing access to, and by the impact of, science and

technology on citizens in all walks of life. Scientific methods and technological innovation inevitably involve challenge to existing tradition. Professor Anthony Giddens, Principal of the London School of Economics and one of the architects of the Third Way, has argued that 'science rests upon organised scepticism – a preparedness to give up even cherished beliefs; upon contestation and the mutual critique of scientific experts'. The post-industrial society is in some measure based on this scepticism and appears to embrace change in a way its forebears in the post-modern society could not. Those who live by scepticism have little or no fear of change. The winning engineering enterprises that focus on creating new knowledge are the engineering enterprises of the post-industrial age.

The Japanese model, much talked about in the early 1990s as the model of innovation and self-organisation, had a number of exemplars: Canon, Honda, Sharp and NEC. These organisations managed to change by exploiting the knowledge held within them – their 'core competence' – and engaged with the post-industrial society. This engagement involved Canon producing 'a small multi-feature product [copier] that could be used by anyone and produced at minimum cost' by involving:

- **knowledge practitioners:** front line employees – researchers and team leaders in different specialisms;
- **knowledge engineers:** middle managers in R&D departments; and
- **knowledge officers:** top managers of different divisions.

Nonaka and Takeuchi, both professors of management, argue in *The knowledge creating company: how Japanese companies create the dynamics of innovation* (1995) that the reason Canon succeeded was that it focused on creating new knowledge. This started with informal meetings between the practitioners to share knowledge across and within disciplines, followed by the 'creation' of new concepts and their justification. The next step was the development of an archetype followed by 'cross-levelling of knowledge' across Canon. The knowledge engineers facilitated discussion amongst the practitioners which lead to the development of archetypes. The knowledge engineers also kept the knowledge officers informed by passing on the essence of the discussions and key features of the archetypes. This close interaction between the knowledge creating 'crew', the practitioners, engineers and officers, was by and large self-motivated and its goal was to precipitate change within Canon.

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Another of the Japanese knowledge-creation success stories came from Honda. The knowledge 'creation' crew at Honda started to think about 'new' automobiles during the 1980s and began designing an automobile which would have more room for humans and less for the machine. New knowledge was required for an automobile which was short in length but tall in height, a concept that was named *Tall Boy*. This design requirement for Honda's *Tall Boy* was contrary to the conventional wisdom of the time which focused on long, low sedans. The knowledge which was created in order to build *Tall Boy* was obtained from the researchers and designers within Honda and from the knowledge practitioners through informal discussions, through exchange of technical drawings, research papers on materials and machines, and the minutes of interminable real (face-to-face) or virtual (internet) meetings. The knowledge engineers and officers played roles similar to those of Canon's in leveraging the new knowledge into a product. There are similar stories relating to NEC and Sharp where the knowledge-creating crew helped not only to leverage the knowledge of the individuals but at the same time justified their concepts to senior management. In the end, each of the companies had a different product to offer and thereby ensured their own survival and prosperity.

The creation of knowledge within any organisation changes the organisation and has an undoubted effect on the people comprising the organisation. Some individuals secure new positions within the hierarchy of the organisation and become part of an elitist network whilst others wither. The key issue here is the trace or the essence of knowledge and how this trace is disseminated.

Management of knowledge and computer systems?

The Japanese examples above, once part of the Japanese 'miracle' folklore, show that expertise can be obtained from individuals and converted into archetypes – prototypes in the case of products and good models in the case of services. Interdisciplinary research teams develop these concepts and archetypes. The knowledge engineers facilitate the knowledge-creation process and the knowledge officers then, in principle, make enlightened decisions. Computers are used to facilitate the flow of work within the organisation in the sense that computers move data and information about from one individual or

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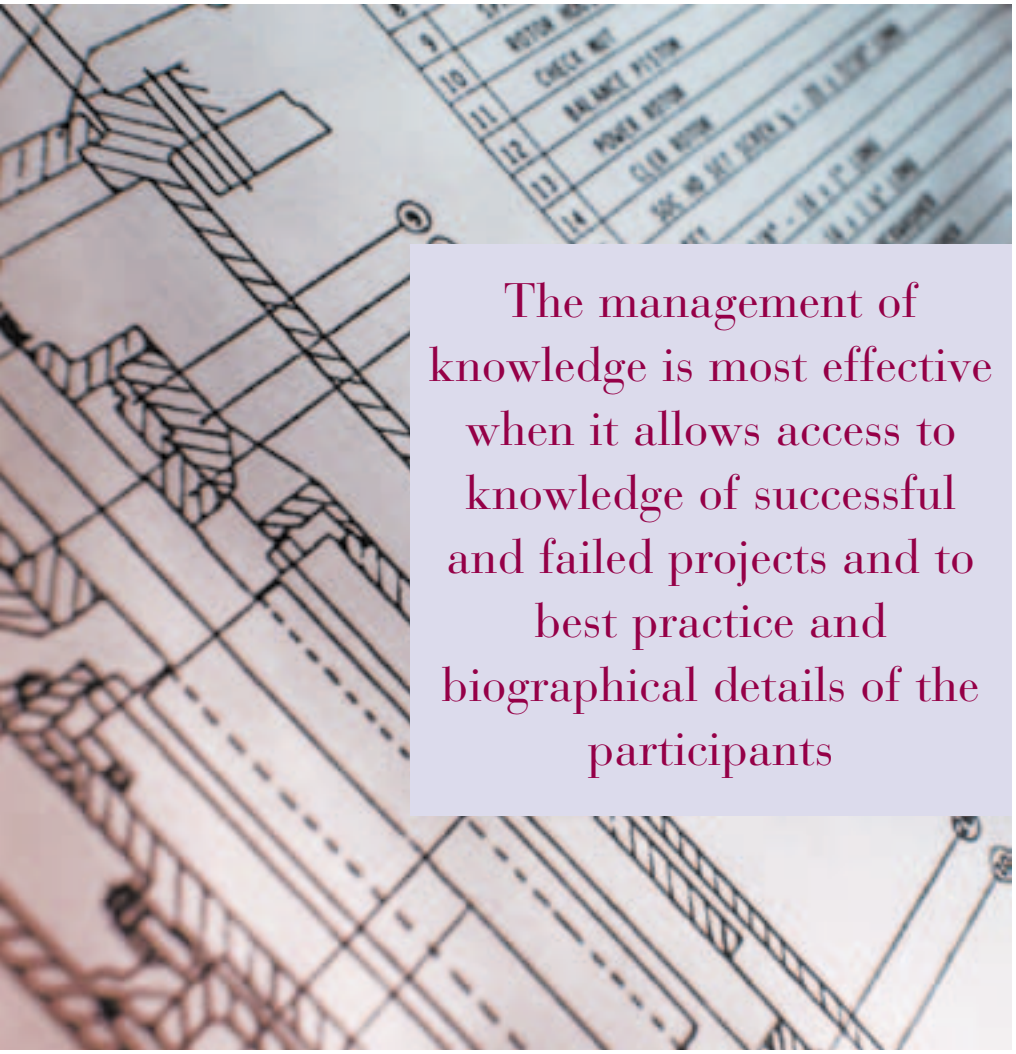
group to another through electronic mail, through the use of shared databases of engineering drawings and research papers, and so on.

Various management consultancies have developed knowledge-sharing software to enable business project teams to communicate and store knowledge. Such a system has been used, for example, to build an enterprise-wide information system for a Venezuelan start-up oil company. Experienced professionals working within the consultancy maintain and update the knowledge of the networks and are able to track the expertise of individuals within the organisation and facilitate co-operation for particular assignments. These networks have been used by organisations including Honeywell, Motorola and Hughes to pool the knowledge of their own employees to bid for contracts.

Hofmann La Roche have used such a system to reduce the time it takes to prepare applications for new drugs; here not only was the knowledge of experts within Hoffman La Roche harnessed but the system was also used to build a knowledge base of the expertise of the various national drug regulatory authorities.

Current knowledge management systems can be viewed as *workflow* systems: systems that deliver work on time to the relevant people and despatch results in time, efficiently and cost effectively from the workers to the managers. There is an undoubted increase in productivity and innovation is facilitated by easy and timely access to information about products, services, human resources and the documents produced by and related to the organisation. A typical workflow system requires agile managers to look after it.



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In the examples above the knowledge-creation crew used a workflow system to exchange data amongst themselves and with others. It appears that one of the important tasks of the knowledge engineer is to facilitate the flow of contents; these contents are the trace or essence of knowledge.

The knowledge management of the future should facilitate the intellectual endeavour of the knowledge engineer in addition to facilitating the flow of documents. This suggests that a knowledge-management system should have some comprehension of the notations and conventions used by humans in communicating orally or through documents. Such a system will have to deal with tacit knowledge, knowledge which contradicts conventional wisdom, knowledge which may be qualitative, or knowledge which is a preserve of the few. The revision of knowledge and the detection of new ideas is usually a task for the knowledge engineer.

Managing knowledge and managing documents

The effective management of knowledge expedites solutions to problems by involving a number of different people within an organisation at different levels and every participant can, if authorised, look at the output of others within the organisation. The management of knowledge is most effective when it allows access to knowledge of successful and failed projects and to best practice and biographical details of the participants.

Whether or not knowledge management is the panacea for some or all of the ailments our societies suffer from, or whether it is the last attack of capitalism on the unsuspecting expert classes and ordinary people, can be debated. What is clear is that if any essence of the knowledge of individuals is left behind, it is usually found in documents comprising words, illustrations and drawings, mathematical and other symbols. A ground-breaking

research paper, a laudable best practice, notes of meetings between leading experts in a specialism or articulate end-users, are all highly condensed versions of the knowledge of the author of the paper, the rapporteur of the best practice, or the knowledge of the experts and end-users involved.

The management of knowledge currently relies on the ability of humans to:

- **locate** and capture relevant documents;
- **extract** terms for indexing documents;
- **classify** documents according to organisational and individual criteria;
- **create** a document database;
- **summarise** documents for quick and easy reading;
- **identify** proper nouns, names of people, places, organisations and proprietary names.

At the University of Surrey, we are focusing on tracking the growth of knowledge within organisations by a systematic and continuous examination of the documents within an organisation and across organisations. Computer systems capable of extracting terms (and also extracting proper nouns) from technical texts and systems capable of summarising and routing texts are being used to study how concepts are transformed into artefacts and how artefacts help in creating and revising concepts.

Our research has been facilitated by System Quirk, which comprises a text capture system, a text analysis system, a term extraction system, a system to create document databases and a text summarisation system, together with a neural-network-based text classifier. The system has been used to study developments in nuclear physics during 1905–1945 by observing how language was used to create this subject.

Rutherford and his colleagues had to argue against the then-conventional wisdom that the atom was indivisible. They conducted experiments and developed ground-breaking theories: the key term Rutherford used was 'nuclear atom' which peppers the discussions, research papers, laboratory notes and letters of the physics community of that time. In order to reinforce the new notion of the divisibility of the atom, the early nuclear physicists coined a number of neologisms: radioactive decay, nuclear reaction, half-life, nucleus which could be heavy or light, nucleus with a radius, with a shape and so on. The reinforcement went further by the frequent use of plurals (nuclei, nuclear reactions, radii) and by preferential and frequent use of nouns made out of verbs (for example, there are very few instances of the word 'react', even in modern nuclear physics literature, but many, many instances of 'reaction(s)'). A whole new way of studying matter was put into place and *named* 'nuclear' physics, and protocols for conducting experiments in nuclear physics were written down.

Linguists have observed that assessments by native speakers of the relative acceptability of words, phrases and grammatical constructs largely correlate with their assessment of the relative frequency of these linguistic units. One can argue that if certain words are more frequently used over time within a scientific discipline, this indicates that experts within the discipline have accepted concepts and artefacts associated with those words. Similarly, if words associated with a

concept are less frequently used over time, then there is a good chance that the concept is becoming less and less acceptable. System Quirk was used to create a digital library of over 50 documents published during the period 1905–1945 by the physics community. Keywords and certain author names were automatically identified and their frequencies computed for each document and for the entire digital library. The frequency measures indicate the rise of the nuclear doctrine and shows how this led to the concept of artificial transmutation of nuclei – the forerunner of nuclear fission and fusion.

Currently we are building a similar word-picture of developments in semiconductor devices, and in particular the yet-to-become-manufacturable quantum devices involving the concepts of tunnelling, stimulated radiation and nanocrystals. We have, in the past, studied the language of automotive engineering, water engineering, safety-critical systems, philosophy of science, modern linguistics and dance.

System Quirk can be used to track research papers or named individuals. Typically, a profile for tracking papers or people is provided by the end user as keywords and/or names of people, places and organisations. The system then launches a search on the internet using commonly available web search engines. The resulting texts are then analysed for their keyword content and classified. If the texts do belong to a particular domain of interest, terms or names extracted from the captured/relevant texts are used to build a revised profile and another search is launched.

Text summarisation is essential for effective dissemination of knowledge; almost invariably we prefer shorter focused documents to longer rambles. Our text summarisation system TelePatten has successfully produced summaries of scientific texts and of newspaper reports. In a competition sponsored by the US Department of Defense's Defense Advanced Research Projects, TelePatten was used to summarise 100 texts. 30 of the 50 intelligence analysts who judged TelePatten's summaries credited them as very accurate.

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System Quirk has been used to extract terminology in languages other than English, including German, Spanish, Catalan, French, Italian and Welsh. System Quirk was developed with EU funding to build a multilingual terminology database for IT, automotive and aerospace engineering organisations. Our partners in EU projects have included Siemens, Mercedes-Benz and Aerospatiale. System Quirk has been used for developing expert systems for the water industry, especially for designing sewerage networks, for extracting water from river systems, and for studying safety-critical issues in the design of water-carrying networks. System Quirk has been used successfully for indexing and cross-referencing major items of legislation for regulating the water industry. Interviews with a number of experts in water engineering and hydrology were analysed by System Quirk for identifying rules and heuristics used. Similar exercises were conducted on existing texts in the specialism. The terminology extracted from texts and existing databases can then be used as input to knowledge bases, thereby reducing some of the bottlenecks reported in eliciting knowledge from experts. This work was supported by the UK Department of Trade and Industry, the EPSRC and the National Rivers Authority (now the Environment Agency).

Afterword

There is much discussion about the intellectual capital of large and small organisations amongst management scholars, sociologists, and in the emergent discipline of knowledge management. Although any change in the material capital – real-estate and finance – of an organisation manifests itself quite clearly by virtue of being physical and tangible, the same cannot be said about the intellectual resources of an organisation. Intellectual capital – the concepts and ideas that give an organisation its distinctive texture – is, by its very nature, constantly changing and is by and large intangible. The umbrella term 'knowledge management' is an articulation of a desire to monitor these changes and unravel this intangibility.

Usually a tangible trace of specialist knowledge may be found in document archives. Such archives generally comprise interview transcripts for experience-based knowledge, notes of best practice, engineering drawings, design and maintenance manuals, past project reports and research papers. If we are to talk seriously of knowledge management *systems* then we have to think how knowledge – or more accurately its trace – is disseminated, particularly through the medium of language. The effective management of the documents emanating from organisations is perhaps the first step in the effective organisation of knowledge. ■

System Quirk is available on the University of Surrey's website: www.computing.surrey.ac.uk/ai/SystemQ