On the Concept and Types of Knowledge

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Abstract. Knowledge is a concept that has gained importance in recent years because of the interest in knowledge management. One of the critical steps before embarking on any knowledge management initiative is to understand the concept of knowledge, so as to be able to identify the sources of knowledge in the organisation and to answer fundamental questions that will guide the design of knowledge management initiatives. Unfortunately, many practitioners rush headlong to roll out knowledge management in their organisations either without giving the object of management, i.e., knowledge, some thought, or with a narrow and parochial notion of knowledge. The objective of this article is to survey the concept of knowledge as seen from the perspective of scholars from various disciplines and to highlight the general and specialised typologies of knowledge. Only with a conceptual clarity of knowledge and an awareness of its various types can knowledge managers begin to craft effective knowledge management initiatives for their organisation.

Keywords: Knowledge; epistemology.

1. Introduction

Today, organisations are striving to better manage their knowledge and the people who create and possess it, their employees. With deliberate and systematic management, it is hoped that the organisation can better utilise and leverage their knowledge, and bring it to bear on opportunities and problems that confront it. Unfortunately, although there is great interest in knowledge management, little attention has been paid to the object of management — knowledge (Blumentritt and Johnson, 1992). Many practitioners rush to roll out knowledge management programmes for their organisations only to realise that more attention should have been devoted to understanding knowledge before implementation. It is important to note that because the smooth running of a prison, manufacturing plant, non-profit organisation, workshop, and conservatory depend on different knowledge bases, knowledge management implementations in each will be have to take this into consideration.

Scholars from many fields, education, library and information science, and music, for example, have developed perspectives, definitions, and taxonomies of knowledge, and it is important to understand the various viewpoints, if an effective knowledge management initiative is to be designed. An understanding is required to answer the following questions:

1. What types of knowledge exist in my organisation?
2. Of the types of knowledge that exist, what types are critical to the survival of the organisation? What types does the knowledge management initiative seek to manage?
3. What techniques are we to use to manage each type of knowledge that has been identified? Is a single technique appropriate for all the different types of knowledge?

2. Perspectives on the Concept of Knowledge

Spender (1998) alludes to the complexity of the nature of human knowledge and notes that it has puzzled philosophers for thousands of years without any single framework gaining general acceptance. It is no surprise then that the term knowledge has been defined in many ways, and from many perspectives, from that of the practical to the conceptual, including even the philosophical. Because of this, Spender urges that “every attempt to use the concept of knowledge in organisational analysis [...] be preceded by an explanation of its nature” (p. viii). Three perspectives on knowledge have gained prominence: knowledge as potential, knowledge as an endpoint in a continuum, and knowledge as an object verses process.

2.1. Knowledge as potential

Churchman (1971) states that knowledge is the by-product of inquiry, and can be considered either as a collection of information, or as an activity, or as a potential.
However, conceiving knowledge as a collection of information “robs the concept of its life” (p. 10), and fails to portray its vitality and its ability to make an enormous difference in the world. Furthermore, knowledge resides in the user and not in the collection of information. On the other hand, conceiving knowledge in action is pragmatic, but problematic. He gives the example of a carpenter who is knowledgeable about carpentry when he is making a joint (knowledge in action), but is still knowledgeable about carpentry when he is having a meal, or even asleep. The state of being knowledgeable about carpentry is not lost when he is not doing carpentry work. Churchman therefore argues that knowledge is best conceived as a potential of a very powerful sort, one that allows a person to adjust his behaviour according to changing circumstances and affords him the ability to turn data and information into effective action (Applehans et al., 1999).

2.2. Knowledge as the endpoint on a Data–Information–Knowledge Continuum

Bell (1999) bemoans the conflation of the terms data, information, and knowledge which have become inter-changeable in use. He defines data as sequences of events or statistics in an ordered fashion. Meaning distinguishes information from data, and includes knowing about news, events, and happenings. The significance of the meaning of news, events, and happenings, verified by context or theory, then, constitutes knowledge. Judgments, which arise from the desire to re-order, re-arrange, and re-design what one knows, are involved in the process of conversion (Fig. 1).

Davenport and Prusak’s (1998), also in the continuum school of thought, describe data as a set of discreet, objective facts about events, usually stored in a computer. Information is derived from data through contextualisation, categorisation, calculation, correction, or condensation, and can take the form of a message in a document, or visible or audible communication. Knowledge in turn, derives from information through comparison, conversation, and the making of connections to previous knowledge (Fig. 2). They define knowledge as “a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information” (p. 5). While knowledge originates from and is applied by humans, it is embedded in documents, repositories, and in organisational routines, processes, practices, and norms.

Haywood (1995) and Bierly et al. (2000) extend the continuum beyond knowledge to include the concepts of wisdom and insight. Haywood describes the mental journey through which understanding is constructed as one which begins with the presentation and acquisition of data, moving through the key stations of information and knowledge, and on towards wisdom and insight. Bierly et al. (2000) stress that organisational wisdom, the judgment, selection and use of specific knowledge for a specific context, is an important, albeit missing, construct in the knowledge-based theory of the firm. Data is the most voluminous information takes up less space, and knowledge is the least voluminous (Applehans et al., 1999).

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1 Many variations of the point-on-a-continuum model exist. Insertions have been made, e.g., Ackoff (1989) inserts “understanding” and Förd (1997), “intelligence”, between knowledge and wisdom. Tuomi (1999), on the other hand, reverses the order of the hierarchy. He points out that the conventional data, information, knowledge hierarchy is misleading in many situations and proposes an alternative model in which the order of the three elements is reversed. He calls this the “reverse knowledge hierarchy”. He argues that knowledge ought to come first as it is first used to fix the semantics (meaning structure). This structure is then used to represent information, and only then can data emerge. Here, knowledge plays the critical part of constructing well-defined semantics, without which data cannot be created, and hence has to exist before data comes into being.
2.3. **Knowledge as an object (stock) or as a process (flow)**

Knowledge can be viewed as an object that exists independently of the knower. In this case, knowledge is equated with patents, reports, mathematical or chemical equations, or blueprints that can be captured, distributed, measured, and managed. Alternatively, knowledge can also be viewed as the process of knowing and sensemaking. Here, knowledge is inseparable from the knower, and is indeed meaningless in the absence of the knower. Only humans are capable of being knowledgeable, not books or databases. Because of this, the act of knowing can only be nurtured, encouraged, guided, and motivated. Emphasising knowledge stock to the detriment of knowledge flow is a pervasive knowledge management error (Cohen, 1998; Fahey and Prusak, 1998; Davenport and Prusak, 1998).

The different perceptions of knowledge give rise to the different perceptions of knowledge sharing. If knowledge is viewed as a potential of a special sort, something which is seen as a source of power and has the ability to confer exclusivity and uniqueness to a person, knowledge sharing will be perceived as sharing the fruits of knowledge, rendering the knowledge sharer less powerful, less exclusive, and less unique. This is expected to be pronounced in cultures that measure high on individualism where the accomplishments of the individuals are valued. Knowledge-sharing in this case will be avoided. If one views knowledge as an endpoint on a continuum reachable only after arduous efforts in adding value to forms of lesser value, the same consequence can be expected. Knowledge-sharing will be avoided as knowledge-sharing will be seen as giving something which one has toiled for.

Perceiving knowledge as objects means that the sharing of knowledge will be equated to the sharing of objects. The emphasis will be on codifying the knowledge so that it can be shared, harvesting knowledge, building warehouses to store knowledge, and mining the contents of the warehouse. Here, knowledge sharing will be equated to contributions to document repositories and sending emails with file attachments, as objects embodying knowledge are being made available to others, and hence “shared”. Perceiving knowledge as process emphasises the process of knowing, sense making and constructing reality. The emphasis will be on the environment in which knowledge sharing occurs, and this will include the organisational culture, the experience of knowledge sharing, the psychological safety necessary for candid sharing and the availability of time and opportunities to socialise.

3. **General Taxonomies of Knowledge**

The organisation is the locus of interaction between different types of knowledge (Spender, 1998). The different knowledge types, originating both from the environment and from within the organisation, interact in a chaotic, inefficient, and iconoclastic way, combining in unforeseen ways resulting in the creation of new knowledge. It is this interaction that enables the organisation to fulfil its raison d’être, i.e. to create knowledge continuously. To understand the role of knowledge in the organisation, scholars in the area of epistemology have made distinctions between the different kinds of knowledge and have proposed various taxonomies of knowledge.

3.1. **Positive versus negative knowledge**

Teece (1998) stresses that knowledge about failures is as important as knowledge about successes. In the same way, knowledge about approaches that do not work is as important as knowledge about approaches that do work. To illustrate this, he uses the example of innovation, which involves a high degree of uncertainty. While it is obvious that a discovery (positive knowledge) is desirable, it should also be recognised that the experience of going down a blind alley (negative knowledge) can be valuable as it can help steer resource allocation into more promising avenues in the future. Honda, the automobile manufacturer, recognises the importance of preserving ideas that are promising though unfeasible at a particular point in time. For this reason, it keeps track of failed development ideas as it realises that they may be successful in the future (Davenport and Prusak, 1998). O’Dell and Grayson (1998) suggest that a reluctance on the part of management to talk about projects that do not work well (negative knowledge) would lead to an anti-knowledge sharing culture.

3.2. **Explicit versus tacit knowledge**

Nonaka (1995) states that there are two kinds of knowledge, namely explicit knowledge and tacit knowledge. Explicit knowledge can be expressed in words and numbers and shared in the form of data, scientific formulae, specifications, manuals, and the like. Tacit knowledge, which includes subjective insights, intuitions and hunches, is highly personal and hard to formalise, making it difficult to share with others. Tacit knowledge is deeply rooted in an individual’s actions and experience as well as in the ideals, values, or emotions he or she embraces. There are two dimensions to tacit knowledge. The technical dimension
encompasses personal skills and the cognitive dimension consists of beliefs, ideals, and values.

Several researchers have amplified the concept of tacit knowledge. Linde (2001) subdivides tacit knowledge further into the more specific forms of social, physical and other knowledge (Fig. 3). She states that narratives bridge the gap between tacit and explicit knowledge, and is especially useful for the transmission of the social form of tacit knowledge. Spender (2003) states that emotion is a type of tacit knowledge. He stresses, using the example of riding a bicycle, that tacit knowledge is more than just the motor skills involved. Tacit knowledge in this case also includes the emotional dimension of being able to live a life that includes the exhilaration of bicycling. Stenmark (1999) suggests that one’s interest, manifested through an indication of whether or not a given document is interesting, is an instance of tacit knowledge.

Nickols (2000) introduces the concept of implicit knowledge (Fig. 4), which is knowledge that can be articulated but has not been. A task analyst, knowledge engineer or other person skilled in identifying the kind of knowledge that can be articulated can often tease implicit knowledge out of a competent performer. Abdulai (2004) uses an iceberg analogy to explain that although the explicit portion of our knowledge base is vast, it represents only the tip of the iceberg. An even larger portion exists in tacit form below the water line (Fig. 5).

Boisot (1998, p. 57) highlighted the three “distinct variants” of tacit knowledge. Firstly, it refers to knowledge that has been internalised over a long period of time to the point that now, it is taken for granted because everybody understands them. Secondly, it refers to knowledge that is not articulated because nobody fully understands it. Thirdly, it refers to knowledge that is not articulated not because no one understands it, but because it will be very costly in terms of time and effort to codify it.

MacKenzie and Spinardi (1995) state that motor skills provide a paradigmatic example of tacit knowledge. They give the example of the knowledge of riding a bicycle. They assert that most people who can ride a bicycle find it impossible to express their ability in words. They also note that there are no textbooks on bicycle riding, and that when a child learns to ride a bicycle, he is not provided with a long list of written or verbal instructions. Instead, an instructor, typically a parent, demonstrates how to ride, exhorts the child to try it for himself, and encourages him along his process of learning how to ride.

3.3. **Blackler’s taxonomy of knowledge**

Embrained knowledge refers to knowledge that is dependent on conceptual skills and cognitive abilities.
Embodied knowledge is action oriented and is likely to be only partly explicit. Zuboff (1988) states that such knowledge depends on people's physical presence, on sentient and sensory information, physical cues and face-to-face discussions, is acquired by doing, and is rooted in specific contexts. Enculturated knowledge refers to the process of achieving shared understandings. Cultural meaning systems are intimately related to the processes of socialisation and acculturation; such understandings are likely to depend heavily on language, and hence to be socially constructed and open to negotiation. Embedded knowledge is knowledge which resides in systemic routines. Encoded knowledge is information conveyed by signs and symbols. To the traditional forms of encoded knowledge, such as books, manuals and codes of practice, has been added information encoded and transmitted electronically.

3.4. Zack's taxonomy of knowledge

Zack (1999) presents a hierarchical typology of organisational knowledge, of which all are required for healthy functioning of the organisation (Fig. 6). Declarative knowledge, or knowledge about, refers to the labels, categories and distinctions used to represent the things important to the organisation. Procedural knowledge, or knowledge how, includes organisational routines and rituals and refers to the understanding of an appropriate sequence of events or the ability to perform a particular set of actions. Causal knowledge, or knowledge why, refers to an understanding of why something occurs. Relational knowledge refers to an understanding of the relationships among or between these types of knowledge.

Coming from a business strategy perspective, Zack (1999) defines core knowledge as the minimum level of knowledge required just to "play the game". As core knowledge is widely distributed among industry members, the firm's long-term competitive viability is not assured by possessing it. Advanced knowledge allows a firm to differentiate itself from other firms, thereby avoiding a head-on competition. Advanced knowledge thus enables a firm to be competitively viable. Innovative knowledge is the knowledge that enables a firm to be ahead of its competitors and to significantly differentiate itself from them. In addition, innovative knowledge often enables a firm to change the rules of the game itself. Zack cautions that knowledge is not static and what is innovative knowledge today will become the core knowledge of tomorrow. He classifies firms into innovators, leaders, viable competitors, laggards, and at risk, depending on the type of knowledge possessed by the firm relative to its competitors.

3.5. Machlup's taxonomy of knowledge

In his comprehensive classification, Machlup (1961, pp. 21–22) distinguishes five types of knowledge using "the subjective meaning of the known to the knower as the criterion".

1. Practical knowledge is useful in a man's work, influencing his decisions and actions. Machlup further subdivides practical knowledge into: (a) professional knowledge; (b) business knowledge; (c) workman's knowledge; (d) political knowledge; (e) household knowledge; (f) other practical knowledge.

2. Intellectual knowledge satisfies a man's intellectual curiosity, and is regarded as part of his liberal education, humanistic and scientific learning, and general culture. It is acquired as a rule in active concentration with an appreciation of the existence of open problems and cultural values.

3. Small-talk and pastime knowledge satisfies the non-intellectual curiosity or desire for light entertainment and emotional stimulation, including local gossip, news of crimes and accidents, light novels, stories, jokes, games, etc. It is acquired as a rule in passive relaxation from "serious" pursuits and is apt to dull sensiveness.

4. Spiritual knowledge is related to man's religious knowledge of God and of the ways to salvation of the soul.

5. Unwanted knowledge lies outside a man's interests, and is usually accidentally acquired, and aimlessly retained.

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Fig. 6. Zack’s (1999) classification of knowledge.
3.6. *Boisot’s stations in the Information Space*

Boisot (1998) defines alternative types of knowledge as stations or positions in a three-dimensional epistemological space, which he calls the Information Space or I-Space (Fig. 7). Three axes, that of abstraction (the extent to which knowledge can be given structure), codification (the extent to which knowledge can be given form), and diffusion (the extent to which knowledge is made available to those who want to use it), denote the three dimensions of knowledge, and define the I-Space. His theory explores the interaction between these dimensions, and the consequences of moving organisational knowledge along them.

3.7. *Wiig’s taxonomy of knowledge*

Wiig (1999) notes that the areas of knowledge required to work effectively in an organisation consist of not only the primary professional and craft knowledge but also an understanding of who to contact and how to treat them in all kinds of special situations. Calling the latter “enterprise navigation knowledge”, he adds that it constitutes the major part of the typical employee’s valuable knowledge. This knowledge is not owned by the organisation, but is possessed by the individual and rented to the organisation.

3.8. *Lundvall and Johnson’s taxonomy of knowledge*

Lundvall and Johnson (1994) propose know-what, know-why, know-how, and know-who. Know-what refers to facts, and is characterised by its ability to be broken down into bits. Know-why refers to knowledge about causality, and eliminates the need for trial and error. Know-why is especially important for technological development in science-based areas. Know-how refers to skills or the capability to do something. Know-who involves knowledge about who knows what and who knows to do what. Know-who also includes the social skills that enable cooperation and communication with coworkers and collaborators.

3.9. *Mokyr’s types of useful knowledge*

Mokyr (2003) defines useful knowledge as the knowledge accumulated when people observe natural phenomena in their environment and try to establish regularities and patterns in them. Useful knowledge is of two types. Firstly, “what” or prepositional knowledge (Ω-knowledge) has to do with beliefs about natural phenomena and their regularities. Secondly, “how” or instructional or prescriptive knowledge (Λ-knowledge), has to do with techniques.

3.10. *Aguayo’s categories of knowledge*

Aguayo (2004) divides knowledge into two categories. Substantive knowledge refers to knowledge of the subject matter that is specific to a field (e.g., knowledge of salmon farming — how to grow and cultivate salmon for maximum production and quality). Entrepreneurial knowledge refers to knowledge of how to monetise or commercialise substantive knowledge (e.g., knowledge of how to promote and market for maximum profit). He then defines a knowledge-based organisation to be one in which there are many more substantive knowledge experts for each entrepreneurial knowledge expert. Aguayo’s typology recognises that the person that has good ideas often requires a person that has good business acumen in order to reap financial rewards from the ideas.

Many examples of entrepreneurial knowledge and substantive knowledge can be found from the literature. Jeffreys (2004) detailed the early efforts to manufacture aspirin in Australia. This started when the Australians had to manufacture their own aspirin in 1915 due to the lack and the unreliability of supplies from the Germany due to the disruptions caused by the First World War and to Australia’s declaration of war (alongside Britain) against Germany. George Richard Nichols (a pharmaceutical chemist) and Harry Woolf Shmith (an amateur inventor and freelance industrial chemist) had the substantive knowledge of producing aspirin, and they managed to manufacture “absolutely pure” (p. 104) samples of aspirin in commercial quantities, but they did not have the knowledge of how to market their product, i.e., they did not have the entrepreneurial knowledge. In the first few months, they sold little aspirin and had to persuade the
suppliers of raw material to extend them lines of credit. By chance, they met George Davis, a New Zealander who was also a master salesman. George Davis immediately devised a plan to increase the sales of aspirin. His plan had four stages: (1) pick a target area (Queensland was chosen first); (2) pack aspirin tablets into packets of three tablets; (3) give the packets free to the public in the target area; (4) back up this effort with as much creative local advertising as can be afforded. His simple four-stage plan worked. Sales of aspirin shot up in Queensland, and the plan was repeated in the other states with similar success.

A similar division of knowledge is applicable in Lewis' (1999) biography of Jim Clark. In 1979, Clark, more famous as the co-founder of Netscape, invented a chip. He called it the Geometry Engine. The Geometry Engine was better able than any chip before it, to render three-dimensional graphics in real time, and paved the way forward for virtual reality. Clark and his students had the substantive knowledge of chip design. With this knowledge, he founded Silicon Graphics with several of his graduate students from Stanford University. The entrepreneurial knowledge came from their venture capitalist, Glenn Mueller of the Mayfield Fund. They provided the knowledge to transform Silicon Graphics into a “stable, well-adjusted, and lasting” (p. 66) institution. Clark himself never wanted to manage Silicon Graphics himself, and knew that he was poorly suited for this task, which involves entrepreneurial knowledge. He wanted to concentrate on designing and building chips and computers of the future, which involves substantive knowledge. The same series of events happened when he founded Netscape Communications along with Marc Andreessen, and started Healtheon, a health portal. In each of the three cases, Clark provided the substantive knowledge in the businesses, but needed to engage what Lewis called a Serious American Executive, to provide the entrepreneurial knowledge to enable him to commercialize his ideas.

3.11. Price’s unique knowledge and non-unique knowledge

Price (1963) differentiates between knowledge generated through scientific activities and cultural activities. Scientific activities produce knowledge that is not unique to the scientist who has created it. Therefore, if Newton or Einstein had never existed, essentially the same knowledge would have been created by other people. On the other hand, cultural activities produce creative contributions that are uniquely personal. Therefore, if Tchaikovsky or Cellini had never existed, their works would have been replaced by quite different contributions. While the creations of the artist are unique, the scientist has only one world to discover, and only the discoverer will be honored. Price’s taxonomy of knowledge is germane to Croce’s (1900) two forms of knowledge, namely, intuitive knowledge (Price’s unique knowledge) and logical knowledge (Price’s non-unique knowledge). Croce differentiates them by making contrasts:

- knowledge obtained through the imagination or knowledge obtained through the intellect; knowledge of the individual or knowledge of the universal; or of individual things or of the relations between them; it is, in fact, productive either of images or of concepts.

Croce (1900)

The critical issue here is of these knowledge taxonomies, which could be used to characterize the knowledge that is shared during VIKS? Would any of the existing taxonomies suffice, or will a new one have to be constructed?

3.12. Knowledge of good and evil

The Bible provides the most profound typology of knowledge. In the book of Genesis, “knowledge of good and evil” is mentioned. The Broadman Bible Commentary (BBC, 1971) stresses that in the original Hebrew, the phrase actually reads “knowledge, good and evil”. In this case, therefore, it is not really a typology but a phrase that is used to denote all of knowledge. There are three points to note about the knowledge of good and evil. Firstly, the way in which mankind acquired it, secondly, what actually does this knowledge encompass, and thirdly, the consequences of its acquisition.

The knowledge of good and evil is not a result of a long period of extensive study and meditation, i.e. it is not a product of learning, but a result of touching and eating the fruit from a tree! The story of the fall of man is a famous one. In a nutshell, the serpent tempted Eve to eat the forbidden fruit by telling her that she will be all-knowing, like God, if she ate it. Eve, seeing that the fruit looked attractive and delicious, and had the ability to enlighten her (having been plucked from the tree of knowledge), decided to eat it and share it with Adam. BBC points out an interesting fact. After eating the fruit, Adam and Eve did not die, but became acutely aware of their differences, and sewed themselves aprons to hide their differences. This is the knowledge of good and evil — a discovery of our differences, not moral or aesthetic discernment. And the consequences of acquiring the knowledge of good and evil? “I” started to replace “we” from then on. What started off as a wholesome relationship with each other ended with alienation from God and from
each other. Man started emphasising their discovered differences and driving the wedge ever deeper instead of focusing on their essential oneness.

3.13. Silent knowledge

Schwalbe (2005) introduces the term “silent knowledge” to refer to the knowledge that enables one to interact with others in various situations — both routine and unusual. Silent knowledge is critical as it enables one to regulate one’s behaviour so as to be a safe and useful participant in social life. This form of knowledge is called silent as it is usually unspoken. As a result, it is more frequently “caught” by learners, rather than “taught” by experts, or read from a book. Schwalbe provided the following examples of silent knowledge: (1) knowledge of acceptable and unacceptable behaviour and dressing when attending a funeral; (2) knowledge of how to blow one’s nose in public; (3) knowledge of how to ask for and to give directions, and (4) knowledge of how to behave during a first date. He stresses that although these acts may appear to be simple, they require a substantial amount of knowledge to be possessed by a person. Silent knowledge also under girds an understanding of the basic rules of social life. Some of these rules are normative, e.g., “always respect the feelings of others”, “do not treat other human beings as objects or animals”, and “do not stare at people”, while others are procedural, e.g., “after selecting your groceries, queue up to pay for them”, and “when participating in a discussion, do not dominate the conversation, but take turns to speak”.

4. Specialised Taxonomies of Knowledge

4.1. The knowledge of design engineers

Stanford University Professor Emeritus of Aeronautics and Astronautics, Walter Vincenti, in his book What Engineers Know and How They Know It (1990), developed an epistemology of engineering design. Vincenti (1990) categorised engineering knowledge into six categories:

1. fundamental design concepts;
2. criteria and specifications;
3. theoretical tools;
4. quantitative data;
5. practical considerations;
6. design instrumentalities.

Fundamental design concepts (FDCs) can be further divided into operational principles and normal configurations. The operational principle is the basis on which individual parts work in concert to achieve the purpose of a device, e.g., the Seebeck Effect is the operational principle of thermocouples. As such, it provides the criterion by which the success or failure of the device is judged. The operational principle also defines a device, i.e., only temperature sensors that work on the basis of the Seebeck Effect can in fact, be called thermocouples. The normal configuration of a device is the general shape and arrangement that have been found to best embody the operational principles. For example, the normal configuration of a car to an automobile designer is four wheels and a front-mounted, liquid cooled engine.

The designer must possess knowledge of the technical criteria appropriate to the device and its use, and of the assignment of numerical values or limits to these criteria. Only with these specified and well-defined can the designer start to work out the details that would be ultimately handed over to the builder. In the early stages of a technology, this knowledge may not be available as learning is still taking place, but engineers strive to eliminate these unknowns as quickly as possible. When there is widespread agreement in the criteria and specifications, they then get embodied in engineering standards, e.g., the standards that govern the mechanical design of shell and tube heat exchanger have been codified in the TEMA (Tubular Exchanger Manufacturers Association) Standards.

Theoretical tools comprise three sections. Mathematical methods and theories are formulae and calculation schemes useful for the quantitative aspects of design work, e.g., techniques for solving differential equations are needed when dealing with vibration. The ability to make quantitative assumptions to simplify calculations is also included in this category. Next, intellectual concepts provide the language for thinking about the device, conceptualizing and reasoning. Concepts that originate from science, e.g., force, friction, mass, etc., tend to have broad applicability, while others have a more restricted use.

Quantitative data are the physical quantities that are “inserted” into the formulae, and they may be obtained empirically, or calculated theoretically. They may also be organised in tables or graphs, e.g., properties of materials. Descriptive knowledge is how things are, e.g., physical constants, e.g., the acceleration due to gravity, or the density and viscosity of fluids. Prescriptive knowledge is the desired state of affairs, e.g., best practices.

Practical considerations are judgments derived from experience in practice. These considerations do not lend itself to theorizing, tabulation or programming into a
computer. These judgments are typically tacit, learnt on the job, carried in the designer’s mind, and defy codification. They include rules that allow rapid design assessments, guess estimates, and the ability to assess the reasonableness of the results of a mathematical calculation.

The design instrumentality dictates how tasks are done. These include the procedures for carrying out the various tasks, ways of thinking, and judgmental skills. Vincenti (1990) identified two procedures: division of a system into its subsystems, and optimisation and where this is not possible, satisfaction (achieving a result that is not the very best solution, but a satisfactory one). Ways of thinking are the mental processes that are employed before and during quantitative design calculations, e.g., “nonverbal thinking”, which uses visual images in the mind, sketches and drawings on paper, and models, graphs, and plans on the computer monitor. Lastly, judgmental skills are used to make pragmatic design solutions. This calls for insight, imagination and intuition, along with a feeling for elegance and aesthetic in technical design. Judgmental skills enable an engineer to balance technical considerations alongside social demands and constraints. The six categories interact intimately and are therefore not exclusive. Some items of knowledge fit into more than one category.

4.2. The knowledge of musicians

Swanwick (1994) developed a model for musical knowledge. In his model, musical knowledge consists of four layers or strands (Fig. 8). Although the layers are typically woven together, they can be separated out for the purpose of analysis. The first level is prepositional knowledge. This is knowledge that is essentially factual or informational in nature. Examples are knowledge that Beethoven composed nine symphonies, that the gamelan originated from Java, and that Guido of Arezzo invented musical notation. Such knowledge can be acquired in non-musical ways such as by reading a book on the history of music. Prepositional knowledge is not the essence of musical knowing as it is musically inert, and is considered second-hand musical knowledge; akin to knowing things about a person rather than knowing the person himself. Having said that, prepositional knowledge does inform a performer’s interpretation of the music, e.g. in determining the tempo or in deciding whether the sustain pedal should be used. An understanding of the history of music is also important to fully appreciate and enjoy the music of any single period. Interestingly, a musician may be able to utilise prepositional knowledge and at the same time be ignorant about the exact labels for such knowledge. For example, a composer or performer may be able to use syncopation, but not know that the effect is in fact referred to as syncopation. Because of this, prepositional knowledge is not the layer of knowledge seen by musicians and music lovers as crucially important to musical knowing.

The second layer is called acquaintance knowledge. This layer consists of aural discrimination, manipulative control, and notational proficiency. The ability to read musical notation and to sight read is important especially in the Western musical tradition. There is also the ability to sense if the performance matches the notation, and to decipher the different sound qualities, or timbres, produced by various instruments to be able to say, for example, “that sound is produced by a string instrument that is plucked, probably a lute.” Lastly, this layer incorporates the ability to coordinate the muscles in a controlled way to render music as indicated by the notation.

The third layer is personal knowledge. This is the ability, by a decision on what tempo to play at, accen
tuation to articulation to employ, and embellishments and nuances to add, of the performer to communicate a sense of expressiveness. In a sense, this layer refers to the ability to interpret music. This ability enables the performer to impart his unique expressive identity on the performance. This signature can be tailored for pieces from the different eras of musical composition and also for different audiences. This knowledge forms the basis of the ability of the performer to deliver music experiences that delight the audience and that result in expressive characterisations such as “soothing and therapeutic”, “lyrical”, “haunting”, or “rich and secure”.

![Fig. 8. Swanwick's (1994) model of musical knowledge.](image-url)
The fourth layer attitudinal knowledge, which refers to the different levels of commitment or affection, which can range from the positive to the negative. This is to say we respond to different music in different ways. One can “absolutely abhor”, “merely tolerate”, or “be in love with” different types of musical styles. The value which we place on music is highly subjective and varies according to age, gender, social context, personality disposition, education, and previous musical experiences. Attitudinal knowledge arises because music is a very private and unique experience. Swanwick (1994) referred to the second, third and fourth layers as first-hand knowledge, which is akin to knowing a person by acquaintance. Further, he stresses that there is no necessity to attempt a verbal articulation of the first-hand knowledge of music as it can be detected “intuitively by listening attentively” (p. 18). Bukofzer (1947) concurs when he wrote that “words cannot render the aesthetic experience of music itself, let alone replace it.” (p. xiv) Indeed, knowledge of music can only come from repeated experiences with it.

4.3. The knowledge of technicians

In his ethnographic study of nine technicians’ occupations, namely, emergency medical technicians (EMTs), science technicians, medical technicians, microcomputer support technicians, automobile technicians, programmers, customer service engineers, library technicians, and radiological technologists, Barley (1996) identified eight types of knowledge possessed by the technicians. Formal knowledge is the scientific and technical theories acquired through formal coursework. This allowed them to keep up with the literature in their respective fields, and was usefully deployed in their daily work, e.g. programmers used techniques they learnt from computer science classes, and medical technologists required knowledge of biological systems, pharmacology, and disease processes to render diagnostically useful information. For technicians, knowledge came alive when they were faced with a problem to solve. As technologies and techniques evolved rapidly, they valued experience (by this statement, what is meant is “knowledge gained by doing” rather than “knowledge gained by many years of experience”) tremendously. This situated knowledge made their contribution to the organisation unique and Barley (1996) termed this contextual knowledge.

Barley (1996) found that a critical part of a technician’s knowledge is the ability to make sense of subtle differences in the appearance of materials and the behaviour of machines, his semiotic knowledge. Colours, shapes, smells, and other sensory cues were particularly important and enabled technicians to spot problems where others could not. Sensory-motor skills allowed technicians to “have a feel” of their instruments (e.g. pipettes) and techniques (e.g. insertion of intravenous needles). In Vallis’ (2000) ethnographic study of craft workers at three pulp and paper mills, he described the importance of sense-data, which was obtained by these workers through an immediate and physical contact with the production process itself:

To “read” the thickness and smoothness of the coating applied to paper coming off the winder of a paper machine, skilled workers often ran their thumbnails across the papers stock as it accumulated at the dry end of the machine. Typically, the workers in the pulping area detected variations in the output by reaching into their pulp washers, pulling out a handful of pulp, and judging its fibre length and pH level intuitively, on the basis of its look, feel, and even its taste. Sound was also important: senior operators often tapped wooden instruments against reels of finished stock, listening as if through a stethoscope for telltale variations in weight and consistency.

(Vallis, 2000, p. 242)

Heuristics or rules of thumb are stories or little pieces of advice that formed the tricks of the trade that often made the difference between the success or failure of a practice. Adherence to a work style refers to the distinct style of practice that is taught to novices and by which masterly technicians were identified, e.g. the authoritative and improvisational demeanor with which EMTs cope with unfamiliar, chaotic and often dangerous situations. Intimate understanding of local idiosyncrasies comprising a history of past decisions, problems and fixes, and materials and instruments available, enables a technician to adapt successfully to the situation at hand, without which even most experienced technician could be rendered helpless.

Lastly, technicians are aware of the knowledge network that is in their workplace, and how to access this distributed knowledge resource. Medical technicians working in pathology laboratories were found to announce puzzling results publicly, and microcomputer technicians were expected to brief each other on the problems they had faced daily. This allowed the community of technicians to know who had previously worked on or encountered specific problems. This knowledge gave them a good knowledge map of the community, and in some cases, this map extended to technicians outside the organisation, e.g., medical technologists in hospitals established an informal network that met regularly to discuss
problems. Microcomputer technicians tap the expertise of technicians they had never met through the Internet. This is what Gibbons and Johnston (1974) refers to as a second-order form of knowledge, or “knowledge of knowledge” (p. 239). It allows the technician to increase his repertoire of problems-solving ability by gaining access to a wider range of possible solutions to a given problem.

4.4. The Knowledge of Chefs and Cooks

In his ethnographic study of four restaurants in Minnesota, Fine (1996) identified three areas of knowledge employed by chefs to perform their work, namely approximations, shortcuts, and tricks of the trade. “Approximations” is the area of knowledge that allows chefs a degree of autonomy to make choices around a zone of acceptable practice. A key aspect of cooking is that it does not demand precision, unlike craftsmanship and carpentry. Therefore, although chefs have recipes, they frequently ignore them, interpret them, and move beyond them, exercising their creative autonomy. Chefs regard recipes as suggestions, not orders, and therefore much cooking involves the addition of approximate, not exact, amounts of ingredients, and cooking (e.g. heating, baking) for an approximate, not exact, amount of time. One example is the preparation of stock. What is added to stock is a matter of convenience rather than planning. Stock cooked on each day is different, and the chefs are confident that it will not affect the evaluation of the meal and will pass muster. Approximations is an important area of knowledge in cooking as chefs can get away with a level of imprecision denied to other professions. This level of imprecision is possible in the culinary world as the customer’s memories of flavours are not so precise as to distinguish between tastes not dramatically different. “Shortcuts” are techniques that allow the chefs to bend or break the rules of production, and in doing so saving time and effort. Many chefs are aware of these techniques but may not employ them unless necessary because of the effects on the quality of food prepared. Examples of these culinary trade-offs are like the use of instant whipped cream instead of cream whipped by hand; the use of the microwave oven to defrost food instead of defrosting food “naturally” in room temperature; and the reusing of pans to prepare most dishes, only wiping it out instead of washing it, to remove the flavour of the previously cooked food. The knowledge of shortcuts also includes the knowledge of when a shortcut should be used as the over-reliance on shortcuts attracts the scorn of other chefs. Although approximations and shortcuts are known to the public, novice chefs and home cooks tend to avoid them as they are unsure of the effects of using the techniques on the cooked food.

“Tricks of the trade” are techniques that are primarily known only within the occupation. These techniques “transform a difficult, time-consuming task into one that is easier, without a loss of quality” (p. 36). Examples are using soapy water to “perk up” parsley; using illumination to make roast beef appear rarer or less rare that it actually is (essentially, holding red light closer to the sliced meat makes the beef appear rarer, holding it away from red light makes the beef appear less rare); and searing steaks on the grill to add the distinctive grill marks then baking them in a conventional oven as most customers cannot differential between a steak that has been grilled versus one that has been baked. Tricks of the trade are also used to correct mistakes, e.g. hiding cracks that appear in cakes during the baking process with topping or whipped cream.

5. Conclusions

The concept of knowledge has become important because of the current excitement about knowledge management. However, most discussions on knowledge have centered around the notion of knowledge as an intermediate station in mental journey towards wisdom. It will be useful for knowledge managers to consider alternative notions of knowledge. In this article, a broad survey of knowledge from different perspectives has been made, namely, knowledge as a potential, knowledge as a point on a continuum, and knowledge as an object versus knowledge as a process. In addition to this, several general specialised taxonomies of knowledge from four occupations have been reviewed.

References


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2 La Pomme de Terre, The Owl’s Nest, Stan’s Steakhouse, and The Twin Cities Blakemore Hotel.


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