Chapter 6
The Knowledge Management Perspective

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> The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge.
>
> —*Stephen Hawking*.

Abstract An important element of product lifecycle management (PLM) is knowledge management (KM). KM helps manage risks inherent in products as they increase in complexity, and the organisations and teams who design build operate and support the products may be dispersed in geography and time. Economic pressures are also forcing organisations to do more for less with fewer resources in reduced time. It is essential that knowledge is exploited if these efficiencies are to be made. This chapter explores problems with Knowledge Management, posits definitions that may be useful about the nature of knowledge and its relationship with data and information.

6.1 Problems with Knowledge Management

Knowledge management is hackneyed and may be regarded by many as a management fashion that is declining Grant [6]. Many who label themselves as KM system vendors are from the Information and Communications Technology (ICT) domain, where their systems enhance electronic communications, data processing storage, linking and retrieval. Although these ICT systems are important and potentially valuable they only address a fraction of what needs to be considered when implementing or running a KM system.

Many people believe knowledge can be treated as an object that can be externalised from people. Objects can be managed, and therefore the whole term knowledge management is a valid concept if objectification of knowledge is possible.

One of the foundations of knowledge is the relationship between data, information and knowledge. These concepts are ill defined and the terminology used in them is often interchanged. Many people also hold that ICT systems are able to produce information and knowledge. If ICT KM systems are dissected, it is plain

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that the ability of machines is limited to data processing, inferring new data or control (via a set of encoded rules). This is true when the latest state of machine learning or artificial intelligence is considered.

An important aspect of KM is that Intellectual Capital and experts need to be identified within an organisation. This ensures an organisation can ensure the preservation of knowledge in its experts. However, by its nature tacit skills may be difficult to recognise.

We will explore the true nature of knowledge and show that knowledge is intrinsically associated with people, and that 'knowledge facilitation' may be a better concept if organisations want to exploit knowledge for competitive advantage. If you are of the opinion that a KM system implementation is purely a technology problem that can be safely delegated to the IT department, you need to read this chapter.

6.2 What Is Knowledge?

In order to understand how KM should be applied, it is necessary to describe the nature of knowledge itself, and review some existing models that help define and provide a solid basis for development.

Knowledge is often described in two forms, called tacit and explicit knowledge.

Explicit knowledge is that which may be encoded and written down, it may be expressed, consciously rationalised and treated as an object. This form of knowledge can be externalised from the human mind, stored, shared and re-used by different people. Tacit knowledge is skilful action based on experience and knowing how to do something. This knowledge cannot be encoded or written down, but facets of skilful actions may be expressed and discussed in the company of a set of skilful practitioners who often develop their own set of semantics that describe the nuances of their tacit knowledge, but this set of semantics does not externalise tacit knowledge, and tacit skills cannot be learned from it in isolation.

Polanyi [11] is attributed for initially defining tacit knowledge uses an example of riding a bicycle as a tacit skill. The tacit knowledge of how to ride a bike is learned by practice, and not by reading a manual. Tacit knowledge is internalised inside humans and cannot be externalised and treated as a separate object. Experts who coach beginners may facilitate tacit knowledge sharing. For millennia, masters and apprentices have practiced this form of sharing tacit knowledge and learning. The medical profession also teaches new doctors by extensive supervised practice in hospital wards before they qualify. Doctors are also very open about consulting with each other, with no loss of reputation.

Tacit and explicit knowledge should not be considered as separate entities, Tsoukas [12], as all knowledge comprises both elements in differing degrees. It is generally accepted that all knowledge must initially be tacitly based (for example reading an academic paper requires the tacit skills of reading, practice in the

scientific method and comprehension before the codified explicit knowledge may be appreciated and the experiments repeated).

If knowledge is comprised of Tacit and explicit elements and tacit knowledge cannot be codified (or treated as if it is an object) then how can knowledge be managed? A more useful term would be to use the term 'knowledge facilitation'.

Explicit knowledge that is codified and recorded should be regarded as data. It is a subset of general data that has been consciously selected and structured with a context in mind by the author. It may be selectively reviewed because of the contextual links, but as a codified corpus, it is not information or knowledge because it is separated from the sense making ability that is unique to human beings. In order to illustrate this the relationship between data, information and knowledge these concepts should be defined. If we research literature for existing definitions, we may be dissatisfied with what we discover.

Data information and knowledge are often interchangeably used or are mixed within a number of definitions. An example of where knowledge management is expressed in terms of, and sounds like, information and data management is taken from the ITIL standard, where KM is recognised as integral to service support of ICT systems:

> The purpose of Knowledge Management is to ensure that the right information is delivered to the appropriate place or competent person at the right time to enable informed decisions.
>
> The goal of Knowledge Management is to enable organizations to improve the quality of management decision making by ensuring that reliable and secure information and data is available throughout the service lifecycle.

This passage assumes information can be encoded and delivered to 'a place', and mixes information and data with little distinction. The reference to a competent person implicitly recognises that they possess the necessary tacit knowledge to act.

The Oxford English Dictionary defines Information as:

> the imparting of knowledge generally.

These definitions contain circular arguments, are inconsistent and unsatisfactory.

This confusion has been deepened by marketing where computerised KM systems are attempted to be differentiated from others by claims they can manage knowledge. This is hype, tacit knowledge cannot be treated as an object and it is therefore doubtful whether it can be managed. Knowledge facilitation may be a better term to use in trying to exploit knowledge.

In reality computer systems may only process data, enabling rapid storage processing and retrieval of data. Computer systems may also be controlled by sets of rules, statistical techniques and the application of machine learning to produce other highly contextualised output data that may be used for automated control or enhanced decision support, but this does not make it a system to manage knowledge or information. An information or knowledge system involves people.

The essence of information is that a human being makes sense of data in a context. A human may synthesize different information from the same data in different contexts. Different humans may also synthesize different information from

the same data in the same context. We all interpret data differently. Human sense making depends on several factors, namely, the person's experience and tacit knowledge, their values beliefs and morals, their context and their situation. Any changes in these factors may result in different information being synthesised from the same data.

In a business domain, when people generally follow well used defined processes with commonly understood goals, then relevant data within that context may be interpreted by different staff familiar with the domain with minimal variation. This is why ICT based KM systems can be valuable.

6.3 The Data Information Knowledge Wisdom (DIKW) Model

In order to illustrate the relationship between data information and knowledge more clearly the Data-Information-Knowledge-Wisdom model first described by Ackoff [1] will be analysed and critiqued. An alternative amended model will be proposed that better describes the relationships and how the role of ICT may better appreciated.

The following observations are offered to help define important terms and concepts

- Data are unrelated facts, however data is not restricted to text or database entries, it may also include anything we perceive through our five human senses.
- Information is data sensed by human beings, where meaning is derived in a context to gain insights. In this description a wider context should be taken for what data is, how it is sensed and interpreted. A smell (data being sensed) may be interpreted as an indication that food is being prepared, where the information in a known context may be that our next meal is nearly ready for consumption and it is time to break off from our current activities to dine. Knowledge that uses this and other information may be that from previous experience once the earliest smells of food have been sensed one should proceed quickly to the food dispensary in order to avoid queuing.
- Knowledge is the repeated use of information to achieve outcomes through thought or purposeful actions; expertise (or tacit knowledge) may be developed by repeated practice to achieve outcomes more effectively or efficiently. Our minds use associations to store our experience of the world.
- Wisdom is the skilful application of knowledge for optimising benefits, with some authors attributing morals, values or religious connotations to wisdom. Some Posit that wisdom has connections to having a soul and use this as a basis to argue that only humans may have wisdom.

The persecution of Galileo and Copernicus provides enough evidence for the author to summarily dismiss the quasi-religious basis of wisdom.

There is also a further problem with wisdom as being a separate entity from knowledge. It may be regarded as a value judgement on knowledge instead of a true transform of knowledge. Wisdom may also be highly contextual and from different perspectives, one person's wisdom may be judged as another's folly with both parties having justifiable reasoning from their own perspectives.

The transform between data and information is also problematic when information and communication technology (ICT) is considered. It is widely believed that ICT is able to process and manipulate information, where it may be more accurate to say ICT is able to process subsets of data that are deliberately selected to be relevant in defined contexts. The selection and contexts may be described explicitly as codified rules that computers obey. Highly relevant subsets of data to a context are not information, as ICT machinery do not have the ability to make sense of the data. The sense making is the essential ingredient that transforms data to information. The only entities (to date) capable of sense making are sentient beings and not machines.

This being said, ICT has the ability to process data and present subsets of that data that are useful in contexts and are able to aid in decision-making. Machines are also able to act autonomously where they have sufficient means of sensing their environment and have a set of rules or models available to them that enable them to operate (in other words control systems). However those machines when taken out of their operating context would not have the ability to adapt as humans can.

This lack of discriminating between selected sets of data that have relevance and value in a given context and wider pools of unrelated facts suggests there may be a useful intermediate step between data and information that help us understand the

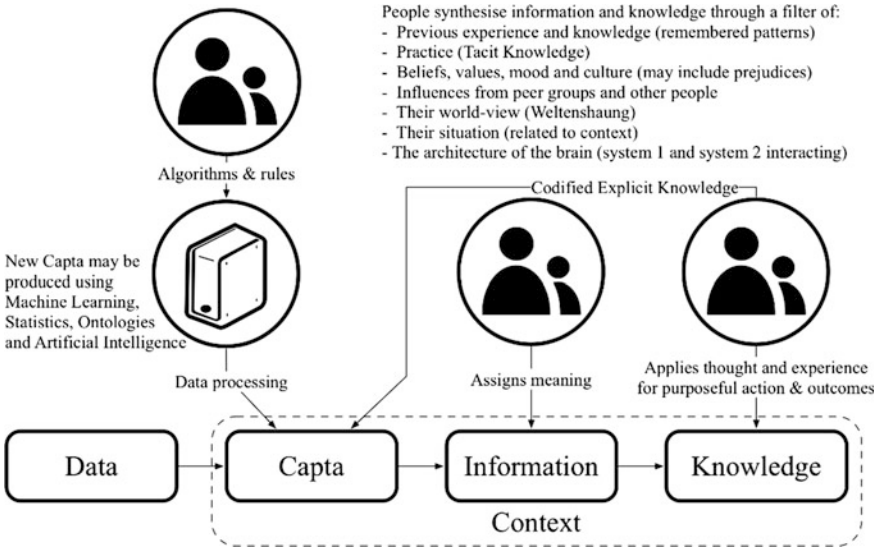

Fig. 6.1 The relationships between data, information, knowledge and the role of ICT and people

true role of ICT in an information or knowledge system. This idea was first suggested by Checkland and Howell [3] where they named these subsets of relevant data, calling them Capta.

The following model is derived from the DIKW model Ackoff [1] first presented. The model is offered as a basic set of defining principles that is useful in helping to architect a useful knowledge facilitation system. The fundamental principle here is that information and knowledge only exists in the grey matter between people's ears. Once this is appreciated it has fundamental ramifications on designing knowledge facilitation systems (Fig. 6.1).

6.4 The Workings of the Human Mind, and Implication on Knowledge Facilitation

Our minds also work in a fundamental ways that are described in Kahneman's [8] book *Thinking Fast and Slow*. Kahanen won a Nobel Prize in behavioural economics for the work he describes in the book. He uses a systems approach that artificially divides the brain into two parts he calls system 1 and system 2. System 1 is the intuitive part of our brain, hardcoded to react very quickly to stimuli (sensing data) without the need to consciously think. This is an evolutionary necessity for survival, initiating rapid reactions to danger to keep us alive. System 1 has much synergy with tacit knowledge in that practice and experience results in actions where we no longer need to use conscious effort to execute them. An example of this is learning to drive a car, where effective use of the car controls is learned through repeated practice, before becoming subconscious (i.e. tacit knowledge). We have all experienced driving home, without conscious memory of the journey when we arrive at our destination. System 2 is rational and lazy, it involves conscious rationalisation of data that costs a lot of personal effort and energy to sustain (to remain focused and concentrated) and compared to system 1, is slow acting. The lazy aspect of system 2 is based on our brain using associative memory that summarises patterns of expected behaviour. An example of this is where we see situations, and our brain simulates and anticipates what will happen next. Optical illusions use these phenomena. There seems to be synergy with system 2 and the concepts of explicit knowledge, where thinking can be discussed and rationalised. Kahneman discusses the interaction of system 1 and 2 in a number of 'heuristics', that describe how decision-making is made and how our judgement may be influenced.

Some of the heuristics discussed include:

- The anchoring effect: This is a subconscious association of being influenced by previously observed quantities. If a person was asked to estimate the price of a bottle of wine, they would give a lower estimate if they had previously been shown the number 5, compared with a higher estimate after being shown the number 30.

- Loss aversion: People are prone to put more effort into avoid losses, than to achieve gains, if we ask a group of people to first choose an option where there is 90% chance of success, and then later choose an option of 10% chance of loss, it is likely the number first choices will be more than the second choices.
- Trusting expert intuition: Intuition is immediate and often subconscious pattern recognition (of past experiences). Experts often have beliefs that are supported by thoughts that easily come to mind when a decision must be made, with no contradictions or competing options. The chance of error is increased when the environment in which the current decision is being made differs from the environments the expert gained their experience and that the expert has had limited practice.

These biases and influences in the way our minds work should be considered in the way Capta is presented, as part of User Experience (UX) design discussed below. UX may be inadvertently misapplied in delivering emotional impact that might prejudice effective decision-making.

6.5 Problems in the Exchange of Codified Explicit Knowledge

During the First World War this communication ([HSTC] [7]) was received by a headquarters from a front line unit in the trenches. The message was relayed by a series of runners

> Send three and four pence, we are going to a dance.

Three and four pence is an example of the British monetary system before decimalisation. It means three shillings and four (old) pence. The original message sent from the trench was:

> Send reinforcements we are going to advance.

This incident shows how a simple and clear message, that has obvious battlefield context that one may have assumed would have increased the chances of an intelligible message being received. This is an example of how codified knowledge may be misinterpreted through a series of senders and receivers to end up as garbage at the final receiver. What possible relevance had petty change for a dance have in the trenches and killing fields of Flanders? Admittedly, the military discipline and attitudes of the time would have suppressed ordinary soldiers questioning the message contents, but they would have also realised and been taught the importance of accuracy to avoid the dire consequences of mistakes in a battlefield context. This is an example that shows us that codified knowledge may not be interpreted as an author intends.

In the corpus of literature on knowledge management, there is surprisingly little written about the effectiveness and efficiency of exchanging and sharing codified

explicit knowledge Gourlay [5]. It is generally assumed that once knowledge is expressed and codified that a person receiving the codified knowledge will make sense of it and interpret it in the same way as the author intended? Common sense and our real world experiences are contrary. The vendors of knowledge management systems, that are essentially data storage and retrieval systems provide simplistic systems that do not address the issue of meaning and interpretation of the message, these are left to the user community to determine.

There are new disciplines developing as a result of the continuing digital and information revolution, examples of these include data science and the development of UX or user experience based design. In the UX domain, software applications (UX is not limited to software) are developed to have superior user friendliness and effectiveness, the older ideas about usability centred on being intuitive and simple to navigate. These concepts are extended in UX—the goal is to achieve a positive emotional impact on the user, the use of the software needs to be pleasurable and a joy. This change in thinking also has great implications on how we should be sharing knowledge, the emotional impact of a receiver of the data has influence on the way they interpret it.

In the design of a knowledge facilitation system, one must consider that codified Capta may not be interpreted as intended. This may be alleviated by UX, and how the richness of data. Image, video and audio messages may convey intended meaning more effectively. A powerful human tacit skill is interpreting body language as an integral part of communication. People often misinterpret the emotional intent in e-mail and can easily take offence where none was intended.

6.6 Cultural Aspects that Support Knowledge Facilitation

The cultural and human aspects of knowledge facilitation are vitally important to address, the following questions are pertinent and must be addressed

1. Why would an expert share their knowledge? An expert may well regard that their political and positional power inside an organisation depends on their retaining their expert knowledge. Knowledge is power. Why would they willingly share?
2. Why should a worker use other's knowledge or insights derived from data? Why would someone trust another's knowledge and if they acted on it and things did not work out would blame still be attached to them?

This indicates that for KM to be successful an organisational culture along with its politics and structure needs to be designed to facilitate the use and sharing of knowledge. Knowledge sharing by experts needs to be recognised and rewarded. The reward structure may also extend beyond money, peer group recognition and respect is an important motivator to experts.

Blame culture also suppresses knowledge re-use; mistakes are only made if lessons are not learned from errors, and that errors can be reflected on openly and constructively free of blame apportionment. The culture should enable open admission of mistakes in a spirit of learning from them. In some cultures the loss-of-face in admitting mistakes or isolating an individual is extremely humiliating and threatening, and so local cultures or international teams should take these factors into account.

Leadership is vital to ensure the culture of an organisation is appropriate for knowledge facilitation, leadership must be seem to lead by example and be open to exploring their own mistakes. There is no such thing as an infallible person, no matter how senior they are.

6.7 Technical Aspects that Support Knowledge Facilitation

The advances in ICT with the emergence of 'big data' and the continuing development of the Internet of Things (IoT) are transformative in terms of exploiting data.

A breakthrough in limitations in the variety of data able to be processed has been achieved, allowing unstructured data to be used. The richness of data has also improved with image, audio and video being able to be exploited.

In memory big data technology also enables data to be processed in near real time, where there may be benefits accrued in agile responses to events in a timely manner.

IoT promises the proliferation of cheap ultra-low-power miniaturised wireless enabled smart sensors that reduce the cost of instrumenting ever smaller assets, and connecting these to the internet. This means a transformative step change in the volume of data we may gather and have access to that will provide unprecedented opportunities to understand product lifecycles in minute detail. A useful roadmap toward exploiting IoT is using big data technology, so that the step increase in data can be analysed.

6.8 So What—How Do We Go About Specifying a KF System?

Knowledge facilitation can only work optimally if cultural, socio, political and technical aspects are considered. The technical aspects of knowledge-facilitation are likely to be the easiest to deal with of the four. An organisation that wholly delegates the implementation or running of a knowledge facilitation system to the IT department is making a mistake. A knowledge facilitation system serves people,

the right organisational culture, attitudes and behaviours are far more important than technology.

Any developed system must have a purpose and deliver benefits. In the context of a full product lifecycle approach, the agreement and incentives for all organisations to participate and reach a consensus needs to be reached. This may best be achieved within whole industries leveraging standards groups, government or internationally backed research groups.

New standards are emerging that require greater exchange of information, with appropriate commercial safeguards for IP, between manufacturers (OEMs) and operators. An example is The American petroleum Institute's 691 standard (API 691), based on a full product lifecycle perspective on Risk Based (rotating) machinery management. This stipulates Failure Modes and effects (FMEA) type data be provided from manufacturers (OEM) to operator customers for machinery that will be integrated into oil and gas plants, in exchange for the operators allowing OEM access in receiving in-service data from these machines, to enable them to improve their product design.

Another example of standards work in industry wide collaboration in sharing data is in Aerospace, with the SAE HM1 committee and their Integrated Vehicle Health Management (IVHM) initiatives, where airline operators, OEMs, regulators and maintenance providers are working out how IVHM predictive maintenance may be safety justified, in gaining 'maintenance credits' so that predictive maintenance can replace traditional planned maintenance.

The effort must be business lead, with a value proposition that clearly indicates the value in facilitating knowledge throughout the product lifecycle.

Historically, and in the author's personal experience of over 40 years working experience in engineering, there is a schism between those who design, build, operate and maintain complex assets. Often machinery is not used as the designer assumed or intended, and the designer does not fully know how machinery behaves when it is operated. Feeding appropriate Capta and allowing people to work in many of the different phases of the product lifecycle will break down barriers.

Cultural aspects: some cultures are more deferential to elders or to seniors within a hierarchical structure. Other cultures may depend on a whole group conforming and agreeing (embodied in Kaizen) whilst other cultures are more individualistic. This paper makes no assertions about the best type of culture to have, as this may be a value judgement. The design of a knowledge facilitation system must take account of and fit the dominant cultures it serves.

Political aspects. Knowledge facilitation implies sharing relatively sensitive data between departments and separate entities that may be threatening to many people. This threatens the success of a knowledge facilitation system as its implementation or running may be resisted. Lifecycle management requires knowledge to be shared over the whole lifecycle of a product. This will involve commercial and intellectual property concerns to ensure individual organisations are not disadvantaged by

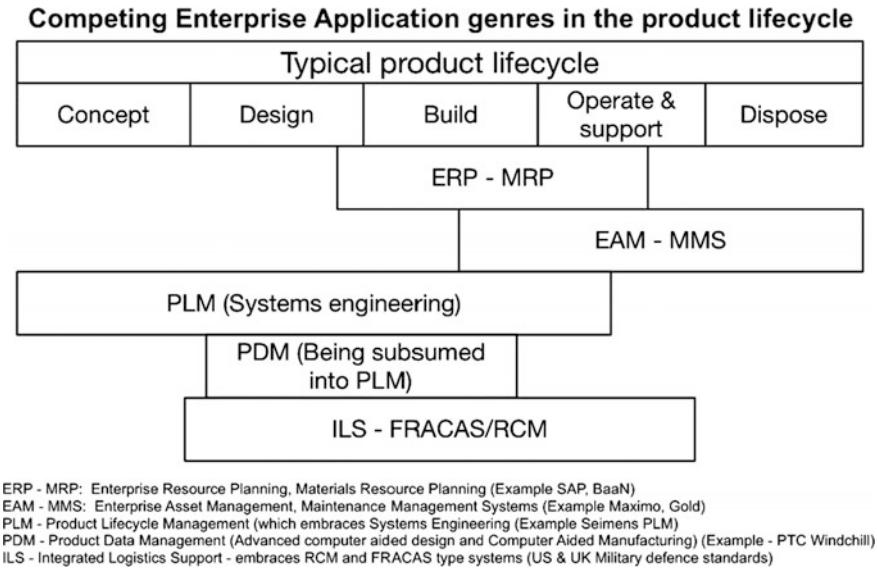

Fig. 6.2 Competing enterprise application genres in the product lifecycle

knowledge sharing. Commercial organisations will need to develop ways of sharing valuable data for the overall benefit of their industries.

Socio aspects: The scenario of incentivising hoarding expert knowledge for power needs to be relieved by making it advantageous to both share and use knowledge. Mentoring, coaching and leadership play vital roles in fostering knowledge sharing. The recognition of Tacit knowledge emphasizes preferment of on the job training and experience, where knowledge transfer will also be more effective if work is openly reflected on. Mistakes should be tolerated to enable learning (Fig. 6.2).

ERP and EAM systems do not embrace knowledge management except that many systems are rolling out big data technology that enables data mining. Examples include SAP HANA that provide in memory data warehousing capability to derive business intelligence.

A good knowledge facilitation system could be built around organisational processes, bringing processes alive, and attracting people into using tools and assistance geared to traversing processes in the most effective and efficient way. Links to data, past examples, both good and not so good, experts (who should be willing and rewarded for helping) may all be integrated into rich media intranet that actively attracts people to use it. The latest thinking and practice from UX (user experience design) should go beyond the usual ‘it should be intuitive to use’ to it will have a positive emotional impact and be a joy to use.

References

1. Ackoff R (1989) From data to wisdom. J Appl Syst Anal 16:3–9
2. API 691 (2016) Risk based machinery management. http://ballots.api.org/cre/some/ballots/docs/B3600_API_691_1st_Edition_Draft.pdf. Accessed 10 May 2016
3. Checkland P, Howell S (1997) Information, systems and information systems: making sense of the field. Wiley
4. Gourley S (2006) Conceptualizing knowledge creation: a critique of Nonaka's theory. J Manag Stud 43(7):1415–1436
5. Gourlay S (2007) An activity centered framework for knowledge management. In: McInerney CR, Day RE (eds) Rethinking knowledge management: from knowledge management to knowledge processes. Information science and knowledge management. Springer, Berlin, Germany, pp. 21–63. ISSN (print): 1568-1300 ISBN: 9783540710103
6. Grant K (2011) Knowledge management, an enduring but confusing fashion. Electron J Knowl Manag 9(2):117–131. http://www.ejkm.com/issue/download.html?idArticle=285
7. [HSTC] 1914 October 15, The temperance caterer, altered in transit, Page 78, Column 2, NA Page 16, London, Middlesex. (NewspaperArchive)
8. Kahnanen D (2011) Thinking fast and slow. Farrar, Straus and Giroux
9. Liebowitz J (2016) Some misconceptions about knowledge management. https://www.k4health.org/blog/post/some-misconceptions-about-knowledge-management Accessed 20 Feb 2016
10. Oxford English Dictionary. http://www.oed.com/viewdictionaryentry/Entry/95568 Accessed 19 Feb 2016
11. Polanyi M (1958, corrected 1962) Personal knowledge, towards a post-critical philosophy. Routledge, London
12. Tsoukas H (2003) Do we really understand tacit knowledge? In: The Blackwell handbook of organizational knowledge management, pp 410–27. doi:10.1.1.18.8864