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DEVISING ENABLING SPACES AND AFFORDANCES FOR PERSONAL KNOWLEDGE MANAGEMENT SYSTEM DESIGN

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ABSTRACT

Aim/Purpose	Personal Knowledge Management (PKM) has been envisaged as a crucial tool for the growing creative class of knowledge workers, but adequate technological solutions have not been forthcoming.
Background	Based on former affordance-related publications (primarily concerned with communication, community-building, collaboration, and social knowledge sharing), the common and differing narratives in relation to PKM are investigated in order to suggest further PKM capabilities and affordances in need to be conferred.
Methodology	The paper follows up on a series of the author's PKM-related publications, firmly rooted in design science research (DSR) methods and aimed at creating an innovative PKM concept and prototype system.
Contribution	The affordances presented offer PKM system users the means to retain and build upon knowledge acquired in order to sustain personal growth and facilitate productive collaborations between fellow learners and/or professional acquaintances.
Findings	The results call for an extension of Nonaka's SECI model and 'ba' concept and provide arguments for and evidence supporting the claims that the PKM concept and system is able to facilitate better knowledge traceability and KM practices.
Recommendations and Impact on Society	Together with the prior publications, the paper points to current KM shortcomings and presents a novel trans-disciplinary approach offering appealing opportunities for stakeholders engaged in the context of curation, education, research, development, business, and entrepreneurship. Its potential to tackle opportunity divides has been addressed via a PKM for Development (PKM4D) Framework.
Future DSR Activities	After completing the test phase of the prototype, its transformation into a viable PKM system and cloud-based server based on a rapid development platform and a noSQL-database is estimated to take 12 months.

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Keywords Personal Knowledge Management (PKM), Design Science Research (DSR), Informing Science (IS), Knowledge Worker, Affordances, Path Dependency, Fixations, Digital Ecosystems, Memes, Memex, Knowcations

PERSONAL KNOWLEDGE MANAGEMENT AS INFORMING SCIENCE

This article is the third publication to validate a novel Personal Knowledge Management (PKM) concept and system. Both of the previous papers - like this one - incorporate references to the relevant prior publications covering technical and methodological details and, thus, provide a kind of 'Long Discussion Case' aiming to potentially assist IT researchers and entrepreneurs engaged in similar projects.

In the first instalment (Schmitt, 2015d), the approaches at the heart of the PKM system are put under the IS-macroscope by aligning them against some of the Informing Science's key methodologies (Cohen's IS-Framework, Leavitt's Diamond Model, the IS-Meta Approach, and Gill's and Murphy's Three Dimensions of Design Task Complexity).

The second article (Schmitt, 2016e, 2016j) emphasizes PKM's status as a 'wicked' problem (ill-defined; incomplete, contradictory, changing requirements; complex interdependencies) where the information needed to understand the challenges depends upon one's idea for solving them. Accordingly, it presents a chain of meta-arguments elaborating on the central idea to the PKM concept and system (incorporating notions of complexity, Popper's three worlds, Digital Ecosystems (DE), and a United Nations scenario of knowledge mass production over time), before verifying the resulting development process and prototype system against accepted general design science research (DSR) guidelines. DSR aims at creating innovative IT artefacts (that extend human and social capabilities and meet desired outcomes) and at following thorough design processes (as evidence of their relevance, utility, rigor, resonance, and publishability).

This follow-up paper turns its sight to the beneficiaries of the novel PKM system (PKMS) and the affordances to be bestowed on them. It has been strongly guided by two publications, one addressing network communities with a focus on communication and community-building (Mynatt, O'Day, Adler, & Ito, 1998), and the other aiming to extend this view to collaboration and social knowledge sharing (Cabitza, Simone, & Cornetta, 2015). However, the affordances elaborated on by these authors only partially cover the wider scope of the PKM concept and system which resulted in the repurposing, restructuring, and extension of the affordances frames.

- Thus, the paper will first introduce the notion of affordances – originally introduced as an ecological concept – and point out its shared and differing narratives with Personal KM.
- Then, the common ground in the context of communication, community-building, collaboration, and social knowledge sharing will be addressed,
- Next the further PKM capabilities will be accounted for in form of additional affordances to be conferred. This new level not only provides the ground for qualifying the PKM concept and system as a disruptive rather than sustaining innovation (Schmitt, 2016g) with the potential of becoming a general-purpose-technology (Schmitt, 2015h), it also provides the overdue means to support knowledge workers as well as ambidexterity (Schmitt, 2016d).

THE NOTION OF AFFORDANCES IN A WORLD OF ECOSYSTEMS

From Gibson's ecological point of view, "the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill." Accordingly, he exemplifies "what the environment affords animals, mentioning the terrain, shelters, water, fire, objects, tools, other animals, and human displays" (Gibson, 1979).

Subsequently, Briscoe (2010) applied the ecological notion of environments or ecosystems also to information science. He introduced his conceptual framework of Digital Ecosystems (DE) as a means for the cross pollination of ideas, concepts, and understanding between different classes of information environments. This general framework has proven very useful for defining the diverse KM landscape based on a set of key attributes (Figure 1). As the result, the KM environment has been portrayed as layers of interdependent and interacting DEs that differentiate the individual minds (Knowledge Worker) and their social affiliations (Society and Institutions) and that distinguish between physical objects (Technology) and their explicit or encapsulated information or knowledge they contain (Extelligence) as well as their associated sets of ideas or memes they originated from (Ideosphere) (Schmitt, 2016j). Consequently, each DE's affordances – as in the ecological case - differ in what they offer to their inhabitants (agents), what they provide or furnish - either for good or ill.

In focusing on the personal KM context, this paper follows up on the structuring exercise of the KM-specific DEs (Schmitt, 2016j) and aims to stipulate what each of the six layers are able to afford to relevant beneficiaries in terms of objective effects (gains and detriments) as well as subjective perceptions (values and meanings in form of delighters or demotivators).

While all six layers compose the universal habitat, any set of affiliated agents experiences a particular blend of the six DEs due to each of their blend-specific attribute values; such a set has been termed 'knowcations' and resembles a niche in ecology. While a habitat refers to where an agent lives, a utilized or occupied niche refers more to how an agent lives and, thus, represents a - potentially unique - set of attribute values and related affordances (Gibson, 1979). However, contrary to the ecological setting, the affordances provided in the KM context are not just concerned with fulfilling basic survival needs, but aim to empower their agents to manage and further develop their inhabited and utilized 'knowcation' (exploitation and practice), to expand their 'knowcation' (learning and understanding), or establish new ones (exploration and innovation).

Key Attributes:	Technologies Ecosystem	Extelligence Ecosystem	Ideosphere Ecosystem
A: Agent	**Artefact**	**Container of Explicit Knowledge**	**Meme (Business Gene)**
C: Community	Technical Domain/Area	Content Categories	Meme Pools
P: Population	Physical & Service Technologies	Explicitly available World Record	Meme Library of Babel
O: Objective	**Utility**	**Relevance**	**Survival**
M: Means	Fitness for Purpose/Use	Quality of Information	Variation Selection Transmission
S: Structures	Systems & Components	Standards & Formats	Methodologies & Practices
D: Dynamics	Technological Substitutions & Progress	Paradigm Shifts & Scientific Revolutions	Inter- Multi- Trans-Disciplinarity
E: Evolution	Sustaining & Disruptive Innovation	Research & Development	Creative Conversations & Sharing
N: Network	Infrastructures Cloud Internet	Conferences Journals Libraries Knowledge Bases	Meme Paths & User Trails
PKM4D Criteria			
Exciter	Accessibility Easiness	Expressive Creativity	Encouraging Empowerment
Inhabitor	Opportunity Constraints	Daily 'Grind	Overlooked Potentials
Exciter	Operable Autonomy	Collaborative Choice	Technological Progress
Inhabitor	Detrimental Dependencies	Limited Alternatives	Unmitigated Risks
Intervention	- scaping -	- sight setting -	- scaling -

Key Attributes:	Society Ecosystem	Knowledge Worker Ecosystem	Institutions Ecosystem
A: Agent	**Individuum Person Host**	**Knowledge Worker**	**Organization**
C: Community	Acquaintances Contacts	Teams Guilds Professions	Economic & Industrial Sectors
P: Population	People: Tacit & Explicable K.	Prof. Practices, Labor Market	Institutions & Organizational Memories
O: Objective	**Quality of Life**	**Earnings, Career & Reputation**	**Competitiveness**
M: Means	Pyramid of Needs	Attitude, Skills, Expertise	Profitability Exploitation Exploration
S: Structures	Laws & Regulations	Qualification Frameworks	Policies Strategies Action Plans Controls
D: Dynamics	Ethnic Cultures	Professional Cultures	Organizational Cultures
E: Evolution	Nature & Nurture	Education & Life Long Learning	Collaboration & Competition
N: Network	Families Friends Societies	Education Providers & Prof. Bodies	Value Chains & Processes Industrial Internet
PKM4D Criteria			
Exciter	Relational Interactivity	Ecological Reciprocity	Institutional Performance
Inhabitor	Demoralizing Isolation	Restraining Horizons	Collective Misery
Exciter	Creative Conversations	Personal Mastery	Innovative Capabilities
Inhabitor	Discouraging Barriers	Lack of Proficiencies	Wasted Opportunities
Intervention	- socializing -	- striving -	- systemizing -

Figure 1: Attributes of the Six Ecosystems interacting with the PKM System

SIGNIFICANCE OF AFFORDANCES FOR KNOWLEDGE SOCIETIES

Progressing civilizations are based on changes by humans in pursuit of affordances. Due to zero-sum games of competing for limited resources, the benefit of one agent often takes place to the detriment of others, future generations, or the environment. Knowledge, however, is not reduced when consumed and is not lessened when transferred; its view-as-a-resource differs significantly and is destined for non-zero-sum (win-win) interactions.

But, most of this knowledge is subjective and context-specific; its articulation – if possible – often entails generalization, and its encoded representation is "inevitably simplified and selective, for it fails to capture and preserve the tacit skills and judgment of individuals" comprehensively (Lam, 2000). Yet, the inventions of writing, printing, digitization, and the internet and cloud have provided us with the means to make our mental outputs explicit, accessible independent of time and space (Schmitt, 2014b), and consolidatable as a record of the world's extelligence (Stewart & Cohen, 1999).

Hence, the notion of 'Standing on the Shoulders of Giants' implies that no scholarly publication stands alone and that scholarship usually "is an inherently social activity, involving a wide range of public and private interactions within a research community. Publication, as the public report of research, is part of a continuous cycle of reading, writing, discussing, searching, investigating, presenting, submitting, and reviewing" (Borgman, 2007).

Consequently, overall performances and viabilities of institutions and societies rely on the accessible stocks of knowledge, experience, and creativity. Effectively utilized, these stocks convert into innumerable small personal 'nano actions', which combine with larger departmental actions that combine to create consolidated enterprise actions that result in the performance of whole institutions and knowledge economies. As the world becomes more sophisticated and integrated and as the work contexts change with increasing complications and complexity, two needs become ever more vital: to understand how people reason and to understand how to ascertain that they are provided with opportunities, supportive attitudes, and adequate resources to do their best (Wiig, 2011). These adequate resources include affordance-conferring technologies as alluded to by Mynatt et al. (1998) and Cabitza et al. (2015). The novel PKM concept and system offers such a technology and provides overdue support for knowledge workers with the aim of:

- Managing/growing the intellectual, social, and emotional capitals of individuals,
- Supporting their creative authorship throughout their academic and professional careers anywhere and as contributors and beneficiaries of institutional and societal performance, educational services, and the world's collective extelligence,
- Fostering Creative Conversations among teams, organizations, and communities for mutual benefit and competitive advantage via network and cloud technologies.

AFFORDANCES PRIORITIZING COMMUNICATION AND COLLABORATION

By applying the 'Standing on the Shoulders of Giants' notion, it has proven fruitful to revisit a conceptual framework for 'Network Communities' from the pre-Facebook-Twitter-Google-era (Mynatt et al., 1998), although its criteria (persistence, periodicity, boundaries, engagement, and authoring) needed to be re-contextualized to fit the current time and expanded to accommodate the specifics of the PKMS concept. The former task has been already partially accomplished in a paper advocating to go beyond usability and sociability considerations and to devise concepts for the 'Next Community-oriented Technologies' (Cabitza et al., 2015) by shifting the focus from social networking to towards conviviality (i.e., pleasing, gratifying, edifying, self-fulfilling, self-expressive experience) and convivial artefacts (defined as any technology aimed at promoting sociality, cooperativity, self-expression and autonomous and creative intercourses among individuals in order to foster collective deliberation, collective planning, and cooperative action).

This notion of conviviality has also been an inspiration in developing the PKMS concept and prompted the incorporation of the four criteria for 'Capable and Convivial Design' (Johri & Pal, 2012) into a 12-criteria PKM for Development (PKM4D) Framework to be applied in personal settings (Schmitt, 2014k) as well as development interventions (Schmitt, 2016h) in the interdisciplinary and intercultural context. The twelve criteria are closely aligned to the six ecosystems which are also offering a fitting structure for the affordances prioritizing Communication, Community-building, Collaboration, and Social Knowledge Sharing suggested by Mynatt and Cabitza.

Constraints and limitations within the technologies ecosystem

The evolutionary progress of the 'Technologies Ecosystem' is based on a co-evolution of physical and social (including service) technologies directed by business plans (Beinhocker, 2006). Novel technological systems and their components are selected based on their utility and fitness resulting in sustaining (incremental improvements), disruptive innovations (substitutions), or failing products and ideas (Schmitt, 2016j).

Maturing Network Communities, hence, experience different kinds of constraints or limitations over time in both their physical and virtual spaces of interaction, either self-imposed or caused externally. On the one hand, these constraints are "providing a base for the mutual production of expectations about social life within the community" (Mynatt et al., 1998, p. 131); on the other hand, "they require the community to be dynamic, resilient and reactive to unpredictable events" (Cabitza et al., 2015). The technological infrastructure, thus, "has to afford suitable means to support this combination of contrasting conditions" and has to "provide the community members with the awareness of the current constraints, their 'strength' and related 'slack', and to support their activities in accordance and compliance with those; moreover, it has to equally sustain the reflective behavior of the community members that leads to the adaptation, appropriation and continuous redefinition of those constrains with respect to the changes of the contextual conditions" (Cabitza et al., 2015).

The related intervention in the PKM4D Framework is termed 'Scaping' referring to modifying an environment for empowering the capable human resources it accommodates in order to improve 'Accessibility Easiness' and 'Operable Autonomy' for individuals. It ranges from meeting basic necessities (e.g., affording internet access to combat digital divides or access to information and knowledge via effective and affordable artefacts) to supporting individual sovereignty by employing grass-roots, bottom-up, affordable, personal applications (e.g., by affording alternatives to prohibitive approaches and discouraging services of dominant market players) (Schmitt, 2016h).

Cabitza et al. (2015) stress the point that for today's "most popular technologies supporting a community, their development is left in the hand of few big players while the research community is just observing and reporting on their usage in different contexts" and how this state is "stifling the development of real alternatives and the quest for disruptive innovation".

Persistence within the extelligence ecosystem

The 'Extelligence Ecosystem' focusses on developing and making effective use of the available world's explicit knowledge and information. Since successful Network Communities strive on "a growing mutual acquaintance and on an increasing set of conventions that shape the mutual interactions of the community members", they have to employ state-of-the-art know-how and afford members with "durable, although evolving, structures" (Cabitza et al., 2015) of participants, participation, interactions, and content.

The PKM4D intervention is termed 'Sight Setting' referring to the desire to empower citizens by making them highly knowledgeable in order to function competently and effectively in their daily lives, as part of the workforce, and as public citizens (Wiig, 2011). It emphasizes the applicability and productive use of the accessible technologies and extelligence to support the 'Expressive Creativity' and 'Collaborative Choice' of individuals. It ranges from assisting people with their learning and reflection, over developing and articulating their own ideas based on their individual knowledge, back-

ground, and situation, towards guiding the self-determination of their lives and careers and their self-choosing of personal and professional acquaintances (Schmitt, 2016h).

Cabitza et al. (2015) point out that the current and popular social networking sites "do not offer this affordance" because the means to facilitate socialization among their members "are primarily based on a quantitative and merely communication oriented notion of it. From the technological point of view, their persistence is on the one hand guaranteed by the provider once a critical mass of members has been reached; on the other hand, just for this reason, the technological persistence is fully outside the community space of control."

Engagement within the social ecosystem

The 'Social Ecosystem" hosts individual persons' minds interacting with other minds (one's acquaintances and contacts) through their bodies and senses resulting in personal subjective tacit knowledge. Due to communication and the sharing of practices, any collective of individuals (e.g., family, friends, societies) is also likely to establish distinct cultures in this ecosystem which are based on nature (kinship, environment) or nurture (e.g., education) (Schmitt, 2016h).

The kind of interactions a Network Community can afford to its members through the channels provided determines its level of mutual engagement (e.g., by sharing, consenting, endorsing, committing, or collaborating). The degree of individual engagement depends either on the member's choice of participating in the full range of opportunities available or might be restricted according to the services offered to particular roles or forms of membership (Cabitza et al., 2015).

The PKM4D intervention is termed 'Socializing' with the aim of strengthening the personal autonomy and competencies of individuals further by engaging with relevant communities in pursuit of 'Relational Interactivity' and 'Creative Conversations'. Creating and maintaining social ties represent "an investment in the accumulation of social resources or social capital" (Katz, Lazer, Arrow, & Contractor, 2004) defined as the "sum of the resources, actual or virtual, that accrue to an individual or group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition" (Bourdieu & Wacquant, 1992). Since finding and keeping these regenerative relationships will be a key competence, an individual's social capital has to be crafted and nurtured in conscious ways (Gratton, 2011). Accordingly, the affordances range from maintaining and classifying contacts and their talents, over making use of this information by the actual facilitation of conversations or collaborations, towards expediting wider intercultural and interdisciplinary discourses (Schmitt, 2015g, 2016h) as well as experience management (Schmitt, 2017a).

In light of these crucial needs, Cabitza et al. (2015) criticize current social media tools and providers in regard to exclusion (of people without access or account), design control (features imposed on members), content ownership (exploitation of information voluntarily shared by members), and collaborative support (restrictive communication/cooperation-oriented functionalities).

Authoring within the knowledge worker ecosystem

The 'Knowledge Worker Ecosystem' signifies the narrowing of the general 'Social Ecosystem', providing a space for individual knowledge workers as constituents of collective mind sets (e.g., teams, guilds, or professions) engaging in private and professional practices or labor markets. Motivated by earnings, reputations, or career prospects, developing one's attitudes, competences, expertise, and communication skills is key for advancing into desired public or work positions regulated by qualification frameworks and shaped by professional cultures (Schmitt, 2016h).

Hence, Network Communities ought to allow their members not only to use but also to manipulate their space, whether as designers or users. This applies to the interactions produced, but even more so to the social, virtual and physical ecology as being available to participants for continuous authoring and re-authoring in the process of living in and developing the community (Mynatt et al., 1998, pp. 131-132).

The PKM4D intervention is termed 'Striving' and subscribes to a definition of 'Knowledge Worker' which is not restricted to the narrowly defined socio-economic categories of the developed world (as in, for example, Florida's Creative Class (2012)) but follows Gurteen (2006) who places - rather than an individual's type of work - the virtue of responsibility at the center of his reflections: "Knowledge workers are those people who have taken responsibility for their work lives. They continually strive to understand the world about them and modify their work practices and behaviors to better meet their personal and organizational objectives". To Gurteen's mind, these self-motivated "Knowledge workers see the benefits of working differently for themselves. They are not 'wage slaves' - they take responsibility for their work and drive improvement".

The associated PKM4D criteria are 'Ecological Reciprocity' highlighting peoples' desires "to give back to their environment and not just take resources from it, [a vital pre-requisite for a] participative culture and working in a collective milieu" (Johri & Pal, 2012) as well as 'Personal Mastery' referring to peoples' Intellectual Capital in need of being nurtured by building depth and by putting in the time and resources to create a body of knowledge and skills - not only in one single but multiple areas (Gratton, 2012; Schmitt, 2016h).

While all (or most of the) content in existing social networking sites is user-generated, Cabitza et al. (2015) bemoan that the means (and the associated limitations) to produce, share, and consume it, "are imposed from above and subject to change with no notice or consultation (cf., the introduction of the Timeline in Facebook). This contributes to undermining the feeling of being in common virtual place; it corroborates the idea of being guests of some host that houses you (probably just to observe you, or take some opportunity to sell you something); and above all, it totally stifles the community affordance of authoring."

Reputation and trust within the institutions ecosystem

The 'Institutions Ecosystem' is an extension of the knowledge worker ecosystem providing a space for professionals and their stakeholders to form institutions (defined as "snapshots of a sub-set of the ideational field that persevere while the network itself continues to fluctuate" (Kanengisser, 2014)) with organizational intelligence and memories operating in particular economic and industrial sectors. The driving forces are competitiveness and/or collaboration based on capabilities to successfully exploit and further explore and advance institutional portfolios of interests and expertise leading to profitability or reputation and trust (Schmitt, 2016h).

Trust (defined as a "bet about the future contingent actions of others" (Sztompka, 2001)) cannot be afforded directly but has to be earned by acquiring a reputation of, for example, expertise, professionalism, reliability, or high-quality services/content supplied. While Social Network Communities rely on simple reputational metrics based on 'likes', clicks, reads, downloads, or interactions, communities engaged in academic scholarship have established an academic-paper-based citation system that cultivates a sophisticated reputation economy by both crediting the original discoverer and providing a link in a chain of evidence (Nielsen, 2011). Depending on the status of the publisher, a citation adds to varying degrees towards citation indices or impactor factors accessible also online (e.g., Google Scholar, ResearchGate, or Web of Science).

The remaining PKM4D interventions are all related to self-transcendence and seek to further causes beyond individuals' self which may also "involve service to others or a devotion to an ideal (e.g., truth, art) or a cause (e.g., social justice, environmentalism, pursuit of science, religious faith)" (Koltko-Rivera, 2006). Thus, the PKM4D intervention of the 'Institutions Ecosystem' is termed 'Systemizing' and refers to deliberate actions of converting individual into institutional or societal performances. The first criteria 'Institutional Performance' emphasizes the PKM concept's aim of strengthening individual sovereignty and personal utility not at the expense of organizational knowledge management systems, but rather to foster a fruitful co-evolution for mutual benefit. The second criteria 'Innovative Capabilities' acknowledges the need of individuals to acquire a thorough

understanding of how value can be added to intangible services as well as knowledge assets (defined "as nonphysical claims to future value or benefits" (Dalkir, 2005)).

To promote trust and reputation by taking advantage of today's online realities, Nielsen (2011) urges removing barriers that prevent potential contributors in any part of the world from engaging in a wider sharing and faster diffusion of their ideas, sources, data, work-in-progress, pre-prints, and/or code for the benefit of more rapid iterative improvement: "If scientists are to take seriously contributions outside the old paper-based forms, then we should extend the citation system. […] All that's needed for open science to succeed is for the sharing of scientific knowledge in new media to carry the same kind of cachet that papers do today. At that point the reputational reward of sharing knowledge in new ways will exceed the benefits of keeping that knowledge hidden".

Boundaries within the ideosphere ecosystem

The 'Ideosphere Ecosystem' (defined as an invisible but intelligible, metaphysical sphere of ideas and ideation where we engage in the creation of our world (Sandberg, 2000)) represents the entire accumulated explicit human know-how and experience. In Popper's Three Worlds View, this ecosystem resembles his *World:3* which embodies the thought content made explicit in the form of abstract objective knowledge objects, while *World:1* comprises the concrete objects and their relationships and effects in the real physical world (comprising the Technologies and Extelligence Ecosystems presented), and *World:2* refers to the results of the mental human thought processes in the form of subjective personal knowledge objects (comprising the Society, Knowledge Worker, and Institutions Ecosystem alluded to) (Popper, 1972, 1978; Schmitt, 2016j).

A reputable Network Community affords transparent boundaries in respect to its internal and external stakeholders, system elements, and features together with their respective potential or permitted interactions, bearing in mind that "the space in which a network community lives is made up of both a physical and a virtual component: these two components are at the same time distinct and highly interconnected, as one cannot exist without the other" (Cabitza et al., 2015).

The PKM4D intervention is, consequently, termed 'Scaling' referring to an ability that goes beyond its usual financial setting of maintaining or improving profit margins with increasing turnover as evidenced by the two associated self-transcendence-supporting criteria 'Encouraging Empowerment' and 'Technological Progress'. While the former involves helping others to achieve self-actualization, taking avoiding action against 'Overlooked Potentials', and acknowledging responsible leadership and integrity in the process, the latter's focus incorporates removing barriers, reducing complexities, and providing adequate tools to set the stage for an enabling environment and for stimulating the logics and logistics of new knowledge formation (Schmitt, 2015h).

Cabitza et al. (2015) caution that current infrastructures "are not totally adequate to support the interplay between on-line and off-line activities when they mainly afford communication-oriented and information sharing functionalities" while affordances to collaborate across interaction spaces suffer from providers enforcing inflexible exit, entry, and data export barriers at the expense of their captured audiences' attention, time, productivity, funds, and status (Schmitt, 2016g).

Affordances Prioritizing Personal Knowledge Management

As evidenced by the testimonials (last paragraphs of last six subsections), severe deficiencies are hampering communities' experiences and the respective affordances in each of the ecosystems. They impede the capacities of communication, community-building, collaboration, and social knowledge sharing. From a more comprehensive PKM perspective the current state of affairs is even poorer. Figure 2 shows the further key affordances to be introduced as conferred by the PKM concept and system (top section) aligned to a visual summary of the discussion so far.

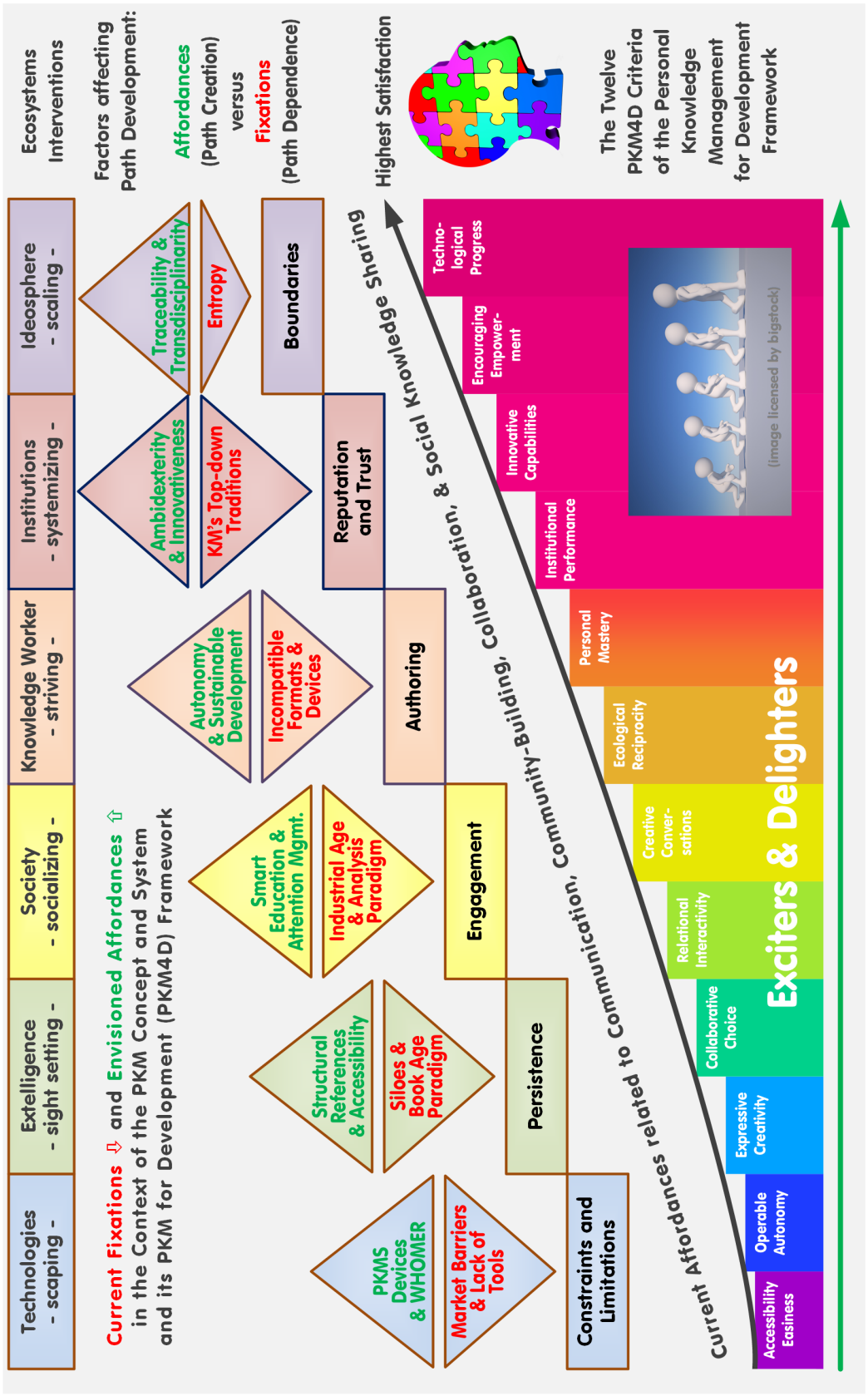

Figure 2: Affordances and Fixations affecting a pioneering PKMS Path Development

These key affordances are presented under the concept of technological path constitution or development which incorporates notions of path dependence (emergence, persistence, and dissolution) and path creation (composition, extension, and abolishment). Since the former describes a situation based on chance or smaller unintended events, the latter calls for deliberate actions. The specific sequence of a path's phases (shown in brackets following a generic timeline of generation, continuation, termination), hence, depends on intentional interventions (Meyer, 2007).

Accordingly, barriers and neglected affordances - as indicated - can be traced to the current market players' (deliberate) emphasis on capturing their audiences through inflexible although inferior services. Their reliance on top-down, heavyweight, prohibitive, centralized developments and institutional approaches might also be deliberate, but could also be owed to path dependence and technological lock-ins due to unconcerned providers feeling secure in comfort and/or ignorance.

Putting path dependence in the wider context of design theory and creativity, Le Masson, Hatchuel, and Weil (2011) label these limited perceptual capacities to sense and adequately respond to changing environments '*fixation effects*'. Their examples cite grounds owed to undue preoccupations with existing, already designed objects, with existing design rules and machine elements, and with non-relevant reuse of existing knowledge. To overcome these fixations, the first step in a repeating cycle is recognizing and acknowledging them, followed by modifying or reinventing their underlying design theories and models with subsequent diffusion, resulting in "enabling new types of innovation output" (pp. 219-220, 230), just like the PKMS concept.

Technologies ecosystem tied to market barriers and lack of tools

The question why a PKM-like system has not emerged earlier (although what Bush (1945) had imagined already seven decades ago as the 'Memex' can be regarded as its as-close-as-it-gets ancestor), has been linked to seven market barriers (Schmitt, 2013e) which led to the formulation of six PKM provisions based on affordances currently not catered for (Schmitt, 2015i): (1) digital personal and personalized knowledge stays always in the possession and at the personal disposal of its owner or eligible co-worker; (2) based on standardized, consistent, transparent, flexible, secure, and non-redundant formats as well as (3) independent of changes in one's social, educational, professional, or technological environment. (4) A 'World Heritage of Memes Repository (WHOMER)' unlocks collaboration capabilities between the decentralized autonomous PKMS capacities (5) which have to be mutually beneficial to facilitate consolidated team or institutional actions. (6) The whole PKM approach needs to be supported by sound educational interventions.

As a result of these neglected affordances, we do have "many powerful applications for locating vast amounts of digital information, [but] we lack effective tools for selecting, structuring, personalizing, and making sense of the digital resources available to us" (Kahle, 2009).

The PKM concept follows Bush's (1945) vision of the 'Memex' and its prototype system is projected to be transformed into viable PKMS device applications supported by a cloud-based WHOMER server based on a rapid development platform and a noSQL-database.

Extelligence ecosystem hampered by siloes and book-age paradigm

Although progress only recently triggered the change from information scarcity to a never before experienced ever-increasing information abundance, the need for managing the scarce personal attention of those receiving it has been stressed by Simon (1971) already over four decades ago. Contrary to this essential need, silos have been created based on proprietary digital formats or incompatible semantic ontologies (Levy, 2011, p. 386) and digital repositories have been fortified by 'walled garden' apps and platforms, counteracting an open and connective web and pleads for a 'new era of networked science' (Nielsen, 2011). Moreover, "the over-simplistic modelling of digital documents as monolithic blocks of linear content, with a lack of structural semantics, does not pay attention to some of the superior features that digital media offers in comparison to traditional paper docu-

ments" (Signer, 2010). The continuing fixation on the outdated book-age paradigm still compels us, as noted by Mintzberg (2005), to provide linear accounts of a nonlinear world.

The PKM concept follows Simon's advice (1971) that producing and transmitting more and more information should not be our sole concern but that we also must know how much it costs, in terms of scarce attention, to receive it: "In a knowledge-rich world, progress does not lie in the direction of reading information faster, writing it faster, and storing more of it. Progress lies in the direction of extracting and exploiting the patterns of the world – its redundancy – so that far less information needs to be read, written, or stored". This PKMS focusses attention by using structural references to re-usable basic information units (ideas or memes just like this paragraph) instead of documents, to be further described in the 'Ideosphere Ecosystem' section below.

Social ecosystem bound by analysis and industrial age paradigm

As argued in prior papers (Schmitt, 2015g, 2016j), three major fixations are adding to the sorry state of supporting knowledge workers in their personal and inter/transdisciplinary capacities:

- Education is still modeled after Ford's Assembly Line and Taylor's Scientific Management, preparing students in disciplinary siloes for the linear, definite, specialized and predictable career paths of the past century (Davidson, 2001) with the exception of Liberal Arts or interdisciplinary programs.
- The myths of Newton's clock-work universe rather than systems thinking and design science are still dominating educational content and academic teachings. While 'design/synthesis' and 'evaluation' top Bloom's revised taxonomy (AECT, 2001), research methodologies, projects, and supervisors are dominated by or preoccupied with 'analysis'.
- Management concepts and models "emanating from the academic discourse fall well short of organizational reality" and lack 'Theory Effectiveness', expecting designs to be purposeful – both in terms of utility (a matter of content) and communication (a question of presentation) to an audience (O'Raghallaigh, Sammon, & Murphy, 2011a, 2011b).

As Levy (2011) emphasizes the need for a personal discipline for collection, filtering and creative connection (among data, among people, and between people and data flows) and points to the sustainable growth of autonomous personal KM capacities as the most important function of future education, the PKM System's innovative features and educational philosophies are about to be aligned to an established Learning Management System. Both approaches are seeking to focus our precious attention by substituting redundant information objects with digitally embedded structural references, benefiting creative authorship and novel learning and collaboration experiences (Schmitt & Saadé, 2017).

Knowledge worker ecosystem seeking autonomy and development

Due to the neglected affordances alluded to, "we still take copies and store them in diverse arrays of devices or make mental notes only. Over time, copies deteriorate, memories fade and with it the ability to recall the locations and contents of our fragmented personal knowledge inventories and archives. Nevertheless, we are unable to part with our accumulated hard and soft copies which slowly but steadily lapse from potential value towards dead ballast." We also "long for better support for identifying and filling knowledge gaps, detecting and correcting flaws, and deciding on suitable means for evaluating and advancing our repositories including the recording of related to-dos, progress, processes, and feedback" (Schmitt, 2012). A brief 'PKM Needs Survey' exemplifies – as a poster based on eleven Flickr images – the challenges knowledge workers are facing (Schmitt, 2014n).

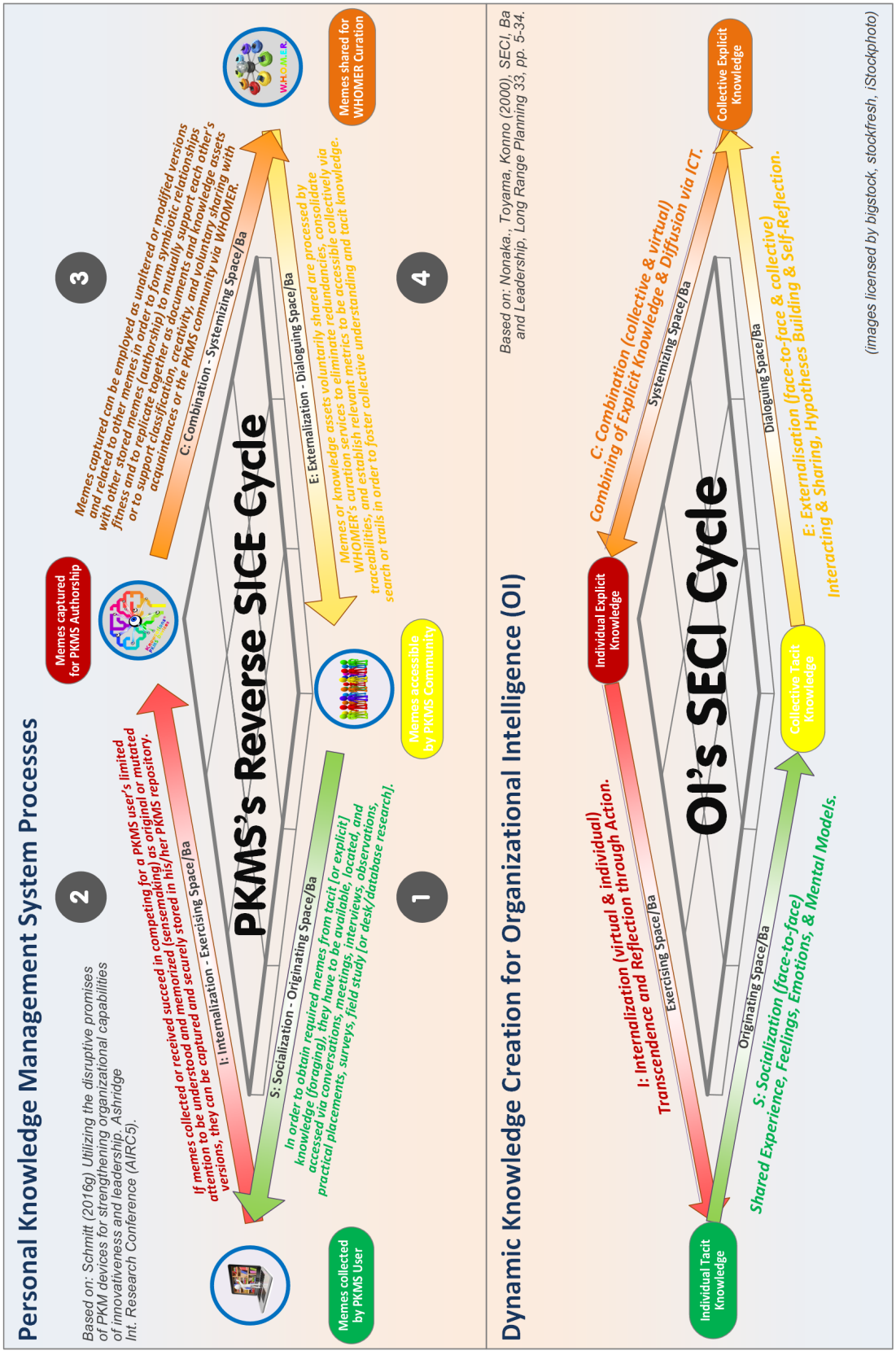

Figure 3: PKM System ICES Cycle versus Organizational SECI Cycle

To address these tasks, the PKMS's Personal Focus affords personal autonomy in handling, mobilizing, and sharing one's knowledge. The upper half of Figure 3 depicts the iterative cycle of this process. It starts with (1. originating/socializing) information gathering via field and desk investigations, continues with (2. exercising/internalizing) selecting the relevant findings to capture them in the PKMS repository, followed by (3. systemizing/combining) utilizing their content and relations by connecting them to related content already present via classification and/or authorship. (4. dialoguing/externalizing) any content can then be voluntarily shared by an individual user with the PKMS community, so that (1. originating/socializing) any individual eligible member can potentially engage with it.

The terms in brackets (1-4) acting as a legend of the cycle presented and fully correspond to the theory of organizational dynamic knowledge creation (Nonaka & Takeuchi, 1995) and its further extension known as the concept of 'ba' or spaces (Nonaka, Toyama, & Konno, 2000). Its SECI Model (depicted in the lower half of Figure 3) promotes individual and collective real-world learning processes in the anti-clockwise manner depicted. Although, as the above cycle description and Figure 3 show, the PKMS cycle - contrary to the SECI-cycle - operates in a clock-wise ICES fashion, it accommodates a very close co-evolution of the two cycles for the benefit of individuals, community members, and institutions as argued in a recent paper (Schmitt, 2016g).

In line with its ambition to tackle opportunity divides, the PKMS's affordances portrayed are aimed to be conferred independently of their users' space (e.g., developed/developing countries), time (e.g., study or career phase), discipline (e.g., natural or social science), or role (e.g., student, professional, or leader) and their focus on Creative Conversations are based on the "emergence of distributed processes of collective intelligence, which in turn feed them" (Levy, 2011).

Institutions ecosystem in need of ambidexterity and innovativeness

The synergies between the PKMS concept and organizational KM systems have been emphasized in the previous section and Figure 3 and have been further detailed in previous articles with regard to KM System Generations (Schmitt, 2015f), integration into Earl's seven KM Schools as well as ambidextrous organizations (Schmitt, 2016d), and disruptive innovations (Schmitt, 2016g).

To utilize these synergies, "the aim has to be to collaboratively interlink and collectively harvest prior accumulated knowledge subsets provided the PKMS user also benefits." In effect, PKM devices accommodate a departure from top-down, centralized, institutional, KM systems towards a more inclusive bottom-up approach. As a result, the PKM concept is able to "underpin a growing dynamic capability for increasing the capacity of an organization to purposefully create, extend, or modify its resource base - including tacit (attitude and leadership), explicit (knowledge bases, rules and strategies), and encapsulated knowledge (products and services) as well as its wider ecosystem (involvement with the community) - not at the expense of disinterested employees but as a means to motivate them and serve their self-interests", bearing in mind that the lack of acceptance of and engagement in organizational KM has been a prime reason for the failure of many KM projects (Schmitt, 2016d).

The future of work and knowledge societies is said to be based on the notion that the knowledge and skills of a knowledge worker are portable and mobile (Rosenstein, 2009). Accordingly, the PKM affordance presented would finally enable individuals - moving from one project or responsibility to another - to take their personal version of a knowledge management system (able to be continually maintained and updated) with them wherever they choose to go and engage. To take a further step, a recent paper has also looked at entrepreneurship and shows how PKM systems can assist in navigating the barriers of the Stage-Growth Business Models (Schmitt, 2016k).

Ideosphere ecosystem fostering traceability and transdisciplinarity

Theory creation and validation constitute important objectives of research to foster understanding in the search for truth and forethought. Conceptual schemes provide an alternative but instead of representing truth they are foremost "evaluated based upon their usefulness to a client". To be useful, such a scheme need to be interesting (meaning it conveys something novel to the client), simple enough (to be communicated effectively), and aware of its own limitations (Gill, 2011).

While the notion of the 'meme' has been enthusiastically picked up by Internet users, it is a highly controversial issue in social sciences and humanities. Major criticisms raised include, for example, its ambiguous definition, its difficulties with quantification and measurement, its nature-culture-analogy's questioned ability of describing complex human behaviors, its dominance of memetic control over human agency, and its doubted value-adding qualities in regard to already existing tools or insights (Shifman, 2013).

As applied in the PKMS context, it closely resembles its original context (by offering a conceptual scheme seeking for usefulness rather than truth) and significantly differs from the 'Internet Meme' commonly applied "to describe the propagation of content items such as jokes, rumors, videos, or websites from one person to others via the Internet" (Shifman, 2013).

Storytelling is regarded as a crucial tool for management and leadership, but the 'meme' meme not only offers an interesting story; it also considerably simplifies the task of rationalizing the substitution of traditional document-centricity with digitally embedded structural references.

First, memes - originally described as units of cultural transmission or imitation (Dawkins, 1976) - evolve over time through a Darwinian process of variation, selection and transmission. In order to 'survive', memes have to be able to endure in a medium they occupy and the medium itself has to persevere. They can either be encoded in durable vectors spreading almost unchanged for millennia, or they succeed in competing for a human host's limited attention span to be memorized (internalization*) until they are forgotten, codified (externalization*) in further objects or spread by the spoken word to other human hosts' brains (socialization*) with the potential to mutate into new variants or form symbiotic relationships (combination*) with other memes (memeplexes) to mutually support each other's fitness and to replicate together (Schmitt, 2016a). [The *-marked terms in brackets refer to both of the PKMS-ICES and SECI cycles discussed, as well as to Figure 3, and, thus, ease understanding by ensuring a close alignability of memes' behavior with the processes of the two co-evolving concepts.]

Second, memetics views memes as 'living' organisms, capable of reproduction and evolution. As a conceptual consequence, PKM's Ideosphere Ecosystem represents the habitat of all memes (or 'business genes' as re-labeled by Koch (2001) to better fit the commercial context). Able to self-replicate by utilizing the human mental storage, memes influence their hosts' behavior to promote further replication (Bjarneskans, Grønnevik, & Sandberg, 1999) and, thus, represent basic (cognitive) information-structures. From a meme's-eye view, every human mind is a machine for making more memes, a vehicle for propagation, an opportunity for replication and a resource to compete for (Blackmore, 2000). So, if memes and their inbuilt ideas are able to flourish in a virtual 'Ideosphere' as their habitat of operation, PKM systems aiming at supporting individual capacity and repertoire for innovation, sharing, and collaboration are well advised to utilize the very same space and resources and to form a digital counterpart of this 'Ideosphere'. Moreover, since the ideosphere can be visualized using a three-dimensional Information-Space Model (Boisot, 2004), the utilities of memes and memeplexes can again be explicitly displayed, this time in form of their amalgamated states as the PKMS user's knowledge assets and his/her capital (intellectual, social, and emotional) together with the steps, regimes, and KM models employed to process them (Schmitt, 2014h, 2016c).

Third, a meme, of course, exists only virtually and has no intentions of its own; it is merely an information piece in a feedback loop with its longevity being determined by its environment (Collis, 2003). In the PKM context, it represents a distinct basic building block of knowledge in the eyes of

the beholder, to be ideally captured and referred to in a quasi-atomic state, perfectly understandable alone by itself, but, being able to be used at any later time - in combination with other meme building blocks stored - without piggybacking irrelevant or potentially redundant information. The PKMS's logics and logistics, thus, afford the recalling, sequencing, and combining of already stored memes with one's own new meme creations for integration in any type of authoring and sharing activity one would like to pursue. The further decomposition of a basic textual, visual, audio, or video meme in its constituent elements (e.g., words, sounds, sentences) as described by Du Plessis (2005) is not required; what matters is how memes are able to morph into increasingly complex memeplexes or knowledge assets (e.g., articles, presentations, or scripts). This process has been exemplified (Schmitt, 2014d) and further clarified by a concept of Dynamic Meme Reuse Classes and Attribute Modifications (Schmitt, 2015d based on Mitchell & Mitchell, 2012) which accounts for just eight ways to change a meme (any combination of reusing or modifying context/symbols and/or content/meaning and/or container/application).

Fourth, while the notion of the six digital ecosystems embedded in Popper's three worlds provides a PKMS meta-level perspective, the conceptual meme scheme affords a transparent grass-roots level foundation. All processes and methodologies incorporated are placed between these two antipodes of the PKMS scale, among them the Extended Ignorance Matrix, PKMS Value Chain, PKM4D Framework, and Design Task Complexity Cube (Schmitt, 2015d). The focus on memes and their digitally embedded structural references represents the most radical departure from the current document-centric KM systems and affords invigorating digital scholarship, individual and institutional curation, and the traceability of knowledge. The latter forms the back-bone of modern manufacturing and stands for the ability to trace the history, application or location of an entity across a whole value chain by creating an as-built genealogy. Its significance for the PKMS concept has been further detailed in two prior articles (Schmitt, 2015e, 2015i).

Fifth, the web created by these traceable memes and their relationships directly supports the educational objectives of the PKMS concept. With all PKM publications captured in their meme-based representations in the PKMS repository, their structural references enable their straightforward repurposing for the educational agenda (in form of e-books, online tutorials, and e-learning course units). The quest for a PKMS solution has pondered on many methodologies advocated by scholars and practitioners. Fortuitously, what might have appeared initially as difficult to reconcile or at odds (e.g., KM's objectives, philosophies, and methods) has resulted in the integration of a few hundred KM tools and ideas which establishes the baseline for a transparent and coherent educational KM concept and KM curriculum, including the rationale of how and why some of the original methods had to be adjusted, extended, re-purposed, or merged, an undertaking further elaborated on in a prior paper (Schmitt, 2016f).

Lastly, only memes are captured in the PKMS repository. However, this does not limit its functionality but enriches it, because – in line with memetics – everything is a meme, including the description of people, groups, communities, and organizations together with their geographic, industrial, service, or research field related classifications, including the references to books, periodicals, events, scripts, databases, standards, testimonials, or artefacts together with their topical references and content, including the intentions, forethoughts, and evaluations representing the user's emotional capital, and including the captured interdependencies between all these entities as permitted by the system. The PKMS knowledge bases afford mirroring the virtual ideosphere and the means for creative connections (among data, among people, and between people and data flows) independent of disciplines, and, thus, offer an overdue tool for knowledge workers and interdisciplinary tasks.

CONCLUSIONS AND THE WAY AHEAD

Through the affordances presented, the PKMS community members obtain the means to retain and build upon knowledge acquired in order to sustain personal growth and facilitate productive collaborations between fellow learners and/or professional acquaintances. Any meme captured is able to

further evolve during learning processes and to form symbiotic relationships with known or newly imagined memes during phases of sensemaking or authorship. As Distin (2005) points out, "In recombination, existing memes are appropriately recombined in new situations, creating new ways of thought and novel effects, perhaps as the result of previously recessive memes' 'effects' being revealed in the reshuffle".

In line with the definition by Cabitza et al. (2015) that affordances "point to the offering or provision of either resources or opportunities to someone who recognizes them and is able to exploit them to become capable of performing some action or get some value or benefit", the investigation into the PKM concept's and system's capabilities has brought to light not only novel affordances but also pointed out current limitations due to path dependencies and fixations.

A further case was made for utilizing the notion of memes as a useful metaphor in support of the PKMS concept together with its educational ambitions. Dawkins (1976) points out three qualities of a meme to enhance its fitness in order to maintain a continued presence in future generations: Fecundity, Longevity, and Copying Fidelity. All three features are profiting extensively from the secure, convenient, and standardized storage in the PKMS's knowledge bases and from the creative conversations between networked autonomous PKMS devices – and so will the world extelligence and its wider-spread accessibility and usability.

Further publications and posters are also under review or planned addressing a PKMS Sustainability Vision, demonstrations and tutorials/workshops, a comparison of how the PKMS trail-network compares to traditional hyperlink configurations based on the set of PKMS publications, and how the PKMS concept compares to, can make use of and add to semantic web technologies. After completing the test phase of the prototype, its transformation into a viable PKMS device application and a cloud-based WHOMER server based on a rapid development platform and a noSQL-database is estimated to take 12 months.

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Ulrich Schmitt's professional background covers positions as IT and management consultant in London and Basle, as professor and vice president at two independent universities in Germany, as well as Vice Rector at the Polytechnic of Namibia and Dean of the Graduate School at the University of Botswana. He studied Management and Industrial Engineering at TU Berlin and Cranfield University, completed his PhD at Basle University, and a Science and Research Management Program at Speyer University. Currently, he is focussing on Personal Knowledge Management and is Professor Extraordinaire at the University of Stellenbosch Business School. See web site for previous and upcoming PKM related work: http://www.researchgate.net/profile/Ulrich_Schmitt2