Knowledge Management 4.0 – lessons learned from IT trends

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One could think that knowledge management (KM) is already fully digitized and therefore the discussion about digital transformation is already too late here. Documents are mostly created digitally for quite some years. Communication is happening mostly in digital form and also cooperation is often fostered by electronic media no matter whether it's video conferences, online collaborative editors or social media that raises awareness for things colleagues are doing. However, the mega trend digitalization stands for more than just electronic forms of data creation, management and storage. It is also about disrupting the world of knowledge workers (KWs)[1] in a similar way that it already transformed media (e.g., Flickr, Instagram, Netflix, Spotify), commerce (e.g., Amazon, Alibaba, eBay) and communication (e.g., Facebook, Skype, Twitter, WhatsApp). The following article highlights those disruptions by discussing three recent trends in the IT sector (namely DevOps, Internet of Things and deep learning, which all have dedicated tracks at e.g. Cloud Expo 2017[1]) and explaining the implications when transferring the insights from IT to KWs in general. The goal is to create a better understanding of the future of knowledge management by using inductive reasoning to infer recommended actions for KWs in general from insights from IT industry [2].

The rest of the paper is structured as follows. First, related work regarding the future of knowledge management in an era of digital transformation is reviewed. After that, four examples of IT trends are presented in a separate section each. Each section is started with a general description of the trend. Then it's transfer to a new application area within the KM domain is derived and illustrated with examples from various fields of work. Each section ends with conclusions from KM perspective (inductive) and for tool support in this area. The KM tasks of Bourdreau and Couillard [3] are taken as a structuration means to strengthen the link to KM. A general summary and outlook concludes the paper.

Related work

Hannola et al. [4] identify four sociotechnical challenges of knowledge-intensive production systems. *Digitally augmented human work* is the next step from paper-based check lists over using mobile devices to see digital information to getting contextual information directly displayed as part of the physical surrounding. *Worker-centric knowledge sharing* is especially challenging, since the interaction with knowledge sharing tools has to be very simple and intuitive, devices have to be more robust and usability as well as technology acceptance for workers has to be taken into account. *Self-learning manufacturing workplaces* are constantly monitoring their performance, are analyzing all available data and are optimizing their parameters to keep production predictable, safe and efficient. It requires linking heterogeneous data sources from the workers' environment and beyond in order to optimize overall equipment effectiveness (OEE). Although largely technology-driven, this challenge also comprises KM procedures e.g. for drawing the right conclusions from data analysis and teaching heuristics about when to trust advice of machines and when to better trust own experiences. *In-situ mobile learning for factory workers* means context-aware learning in real-life situations with mobile devices for continued education and training. The establishment of pervasive learning environments has to be based on a successful combination and re-configuration of interconnected sets of learning objects, databases, data-streams, visualization devices, and relevant HCI concepts.

Thornley et al. [5] develop a KM maturity model that measures the organization's KM readiness for the digital age. They highlight big data as well as the internet of things as important developments influencing KM and stress that judging the trustworthiness and authority of information becoming a new key competency for modern KWs. Knowledge integration rather than knowledge production is another

[1] https://www.cloudcomputingexpo.com/general/topics2017east.htm

key challenge for KM in the digital age. Effective learning from knowledge assets and adapting insights from the past to challenges of the future is also gaining importance. After a focus of KM on documents and unstructured content in the early 2000s and people around 2010, now data analysis results gain relevance for everyday work.

In her research, Holtgrewe [6] analyses prognoses from different institutions and identifies the following trends in the ICT industry which she sees as a role model for future work: 1) restructuring and relocation of work, 2) new and evolving players from India and China, 3) convergence of telecommunications and IT, 4) omnipresent connectivity, 5) cloud computing and big data, 6) employment growth and a perception of skill shortage, 7) flexible employment, as well as 8) virtual collaboration and its limits. Her most important findings from a KM perspective are as follows. ICT workers increasingly need non-technical skills and competencies such as English, project management and organizational skills, attention to customer demands and market developments, teamworking and communication skills, and both creativity and systematic ways of working. Skills shortage is predicted to be high (up to 900,000 missing ICT experts in the EU in 2015), but the problem is also created by companies not willing to invest in training. Virtual collaboration needs a clear division of labor and both tools for fostering knowledge management and established modes of collaboration.

In order to achieve the same productivity increases as the top companies (~30% per year), the big majority of companies has to start using advanced ICT tools as those top companies are [7]. Currently it seems, that the diffusion of innovation is much slower than the development of new innovation. However, Tysman and Kenney [7] see a good chance for lower skilled workers to be able to do jobs for higher skilled workers due to the use of augmented intelligence. This could be in situations, where computers can identify the situation, "know" what to do in that situation and can counsel the person on what to do, although it would be infeasible or uneconomical to completely automate the task. The situation would be somehow contrary to how we usually see machines: persons are smart and know what to do and can use the machine in order to do it, what would not be feasible without the machine. The authors plead for the society to invest in intelligence automation because otherwise the prophecy of ICT displacing work can become self-fulfilling [7]. User interfaces are critical here.

After reviewing related work, own insights into future KM directions are presented and their relation to the findings of the related work are highlighted.

DevOps

"DevOps is an organizational approach that stresses empathy and cross-functional collaboration within and between teams – especially development and IT operations – in software development organizations, in order to operate resilient systems and accelerate delivery of changes" [8]. It can also be seen as a need to develop capabilities such as continuous integration, testing and deployment by using cultural and technological enablers [9]. Examples of cultural enablers are shared goals and values as well as constant, effortless communication. Examples for technological enablers are build, test and deployment automation as well as configuration management (ibid.). Since it is still crucial for software systems to run in an optimized, tested and very specific environment to grant for stability and high performance, the former often separated departments development and operations were joined and either mixed teams of developers and operators now maintain and enhance the systems together, or operators became superfluous, since developers expanded their knowledge into the operations domain and automated operation of the system [10].

Transferred to KWs of all kind, this means that despite all specialization and the need to be an expert with deep knowledge in one area, there is a growing need to also have more than shallow knowledge about related topics [6] like legal, psychological, economical, IT and even production related knowledge. This requires effective learning from knowledge assets [5] and requires foremost to build organizational learning capabilities [3]. Take for example the development of a new generation of a heating system. Today, users expect not only effectiveness and efficiency of the heating, but also interoperability with their smart home system (IT), a user-friendly interface that motivates for energy saving (psychological), low cost in both acquisition and maintenance (economical), high quality and sustainability (production) as well as compliance with data protection regulations despite data being sent to the manufacturer [legal , 11]. Working in a team of specialists of different areas will not lead to success, if team members' knowledge does not overlap to a certain extent, since communication will be infeasible and nobody will be able to think about the overall solution in addition to his or her own contribution to it.

In production settings, for example, the required flexibility and new technologies lead factory workers to perform a wider range of tasks and a pervasive need of overall on-the-job knowledge, which furthermore is subject to continuous change [4]. Electrical engineers that were formerly wiring lights and switches, are now faced with installing building automation systems and need substantial IT knowledge as well as security knowledge to prevent the system from being hacked. Teachers nowadays need media competence as well as legal competence in addition to their social, didactic and professional competence in order to bring teaching material into an appealing form and prevent copyright infringements or students suing them. KM related impediments to DevOps are the requirement to learn more about the other area, which is especially hard given a lack of interest in "the other side" that can be experienced in practice [9]. Furthermore, the capacity of KWs' minds is limited and it can be doubted whether specialists are able to retain their deep level of professional competence while additionally gaining all the other required competencies. However, it is crucial to have more people caring about the big whole KM has to support them.

The second aspect is automation, which helps KWs concentrating on interesting and motivating activities. In DevOps this is achieved with tools that offer a desired state configuration model of a managed infrastructure effectively provide infrastructure as code [12]. It means, that instead of writing down instructions to follow in order to install an application, a shell script or configuration management recipe is written that does the job automatically. Since nearly all infrastructure services such as compute power in form of servers, networking and storing is virtualized now, the required infrastructure for running a distributed application can be dynamically configured. The prerequisite is a managed infrastructure or software defined datacenter.

Transferring this aspect to KWs in general means, that KWs should create more and more electronically understandable and executable artifacts instead of just documents [see knowledge integration , 5]. Instead of writing down instructions on what to do, they will create a BPMN workflow (Business Process Model and Notation), that captures the important notions [13]. If the task is not structured enough for that, they will not write a checklist, but create a CMMN case model (Case Management Model and Notation, [14]) and enrich it with DMN decision tasks (Decision Model and Notation), so that relevant knowledge is captured in a machine understandable and executable form [15]. For supporting business decisions, they will create a data analysis workbook (e.g. with Apache Zeppelin) that references relevant data sources, provides sophisticated analysis methods (as a recording of their own ad-hoc analysis) as well as templates for presenting the results in an appealing form [16]. It is a new form of externalizing knowledge [3], which eases reusing the knowledge (ibid.).

These examples show that more and more KWs need to become so called citizen developers [17]. The term was coined by Gartner and stands for non-IT personnel that however is IT-affine and therefore able to deeply configure IT applications or write own customizations for existing applications with a graphical and user friendly tool. Examples from the past are MS Excel or MS Access specialists who wrote own "applications" based on these tools. In the future, they need new Web-based tools that let them leverage both organization-internal systems as well as public cloud offerings to create mashups that support them in doing their job as good as possible.

The internet of things (IoT)

In the Internet of Things, “information and communication systems are invisibly embedded in the environment around us”[18]. For technology to disappear from the consciousness of the user, the IoT demands: (a) a shared understanding of the situation of its users and their appliances, (b) software to process the contextual information, and (c) the analytics tools that aim for autonomous and smart behavior [18]. Systems are context-aware if they use context, e.g. the five W’s (who, what, where, when, why) to provide relevant information and/or services to the user, where relevancy depends on the user’s task [19]. They could e.g. execute certain actions, like turn on the lights when a user enters the room or notify the user about a certain situation that was detected from various sensor readings.

Transferred to the KW, IoT will enable systems to better understand what users are currently doing and offer context-aware support that includes the physical surrounding. The trend towards connected things will give the KWs the ability to closer connect the digital / virtual and physical / real world with each other. This should aid in both developing new knowledge as well as externalizing and reusing existing knowledge [3]. Meetings cannot only be recorded but also automatically transcribed and translated and the technical progress of the last years makes it probable that the quality of that automatic transcripts and translations will be on par with average human performances in that area. Information can be easily transferred between personal information processing devices like notebooks, tablets and smartphones to shared devices like electronic whiteboards, interactive tables or walls (e.g. using Miracast). Text mining tools will detect to which project or task a document or email belongs, that the user is currently reading and suggest meaningful actions. Automatic identification of dialog partners, location (both outdoor and indoor) and current time will help to track what people are doing and provide them a personal journal that users can extend with notes. Augmented or mixed reality devices like Epson Moverio BT-300, Vuzix M300 or Microsoft Hololens will allow for blending information from information systems with vision of the real world and therefore take the availability of information in context to the next level. The second aspect to be learned is, that natural user interfaces like those using speech and gesture recognition on the one hand, or programmable push-buttons on the other hand will make access to information more natural and direct, which fosters in-situ mobile learning, self-learning and worker-centric knowledge sharing [4].

Situated action/cognition theory says that knowledge is closely bound to creation context including the physical environment[20, 21]. With IoT tools it is possible to better use the physical environment to help KWs more naturally interact with the digital world and therefore distract them less from the task at hand, e.g. a smartwatch that sends a standard-answer to a message with one swipe instead of requiring to get the phone from the pocket, unlocking it and typing the message manually.

Deep Learning

Deep learning is the trend of using artificial neural networks with multiple hidden layers and reinforcement learning in order to learn things that are hard to program in form of algorithms [22]. These artificial neural networks are inspired by what is known about the human brain [23]. “Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics”[24].

Transferred to KWs in general means, that deep learning can even replace KWs by automatisms in a lot of areas, whether its attorney assistants, medical professionals or financial analysts [25]. On the other hand, deep learning can also help KWs do a better job, by automating parts of the tasks that are tedious for humans so that they can concentrate on aspects they excel in. That does also mean, that some jobs will be lost to automation, whereas others are upgraded and need even higher qualification then before. Therefore, KM will need to shift the focus from supporting people to find the right information to supporting them to be able to work in new areas of the company. Due to skills shortage [6], it is increasingly hard for organizations to get skilled KWs from the labor market, especially if companies are not willing to pay exaggerated wages, offer jobs outside the booming large cities or are not creating consumer products with high visibility [26]. In Germany, there were for example 51.000 open IT jobs in 2016[2] accompanied by another 69.000 open jobs for engineers[3]. Therefore, the old strategy of firing employees that work in areas that become automated and hire new employees for jobs that need a different or higher qualification will not work as well in the future.

Organizations need to find ways to qualify existing employees for new jobs, which require at least middle-skills levels of literacy, numeracy, adaptability, problem solving, and common sense [27]. Since it is unlikely that a formerly low to medium qualified employee whose job is automated will leapfrog higher qualified colleagues to take a new job with very high requirements, it seems a better strategy to continuously train people to prepare them for higher qualified jobs so that highly qualified people get an even more demanding job and medium qualified people move up to fill the gaps. Again, building organizational learning capabilities is a key success factor [3]. Maybe, digitally augmented human work [4] or intelligence augmentation as advocated by [7] can help here. Since the current educational systems in Germany or the US are unable to deliver that, companies have to come up with own apprenticeship and workplace learning concepts in order to get qualified personnel. Dual education with workplace learning on the one hand and further education at universities on the other hand, is another possible building block. Already successful today, it has to become more flexible to teach learners what they need, e.g. with nano degrees, and accompanied workplace learning instead of quarreling about which kind of education “produces” better workforce.

Summary and Outlook

The lesson learned ten years ago, that the introduction of information systems is not equal to getting knowledge management is still true. However, the discussion shows, that IT will play an ever-increasing role in society as well as knowledge management and at the same time ideally becomes less visible and less disturbing (IoT). It should offer gentle support where needed but should not demand the user’s attention since attention is becoming the bottleneck of KWs in the increasing fight for awareness of dozens of tasks that a typical KW has to complete every day. The challenge for KM is to not only provide “information at your fingertips” but competency development programs that systematically enable people to effectively and efficiently work in todays and future jobs. This kind of job enlargement (DevOps) might even lead to higher job satisfaction and motivation due to more challenging and diversified tasks and less routine work (deep learning) if they are able to acquire the required competencies. All trends discussed include aspects of automation and therefore less distraction and repetitive work on the one hand, and requirements to acquire new competencies on the other hand. Both aspects should be considered in future KM initiatives.

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