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Work 4.0 and the Identification of Complex Competence Sets

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ABSTRACT

In our progressively more interconnected world, some people may be displaced from their traditional occupations by intelligent agents and smart machines. At the same time there may be a shortage of people skilled in the development of these technologies, and societal changes may see more people undertaking a succession of short-term project assignments. This is leading to studies of future competency requirements (called Work 4.0 in Europe) and the evolution of agile human resources management systems. A focus on mapping accessible individual competence sets is emerging, facilitated by the identification of associated information systems. In this paper we explore challenges in the identification of current and future competency requirements and in competency mapping to facilitate agile operations. We also introduce the concept of competency relationship mapping.

Keywords

Industry 4.0, digital transformation, HRM agility, agile teams, competency mapping

INTRODUCTION

The accelerating introduction of cyber-physical systems and data analytics is changing the way business and work is done. The operating environment created by these elements of data-centric operations has been described as ‘Industry 4.0’ and related elements are shown in Figure 1. Some traditional routine occupations are being displaced (e.g. machine attendant roles), and some new creative ones are emerging (e.g. roles facilitating data analytics and machine learning technologies). At the same time, there are regional and global social and economic dynamics that result in concerted efforts to reskill or upskill significant proportions of the population, drawing attention to the need for mapping our current competencies and those needed for the future.

A study of the impact of digital transformation on professions launched in Germany under the umbrella of ‘Work 4.0’, and the ‘future of work’ is being considered by a variety of organisations, e.g. the World Economic Forum and Boston Consulting Group (WEF, 2019). New professional skillsets and different combinations of skillsets are needed (Hess et al, 2015).

The emerging business environment also highlights a need for enterprise agility to quickly adapt to changing circumstances, including the need to understand the attributes of an agile workforce (Sherehiy and Karwowski, 2014). In addition, agile project management ideas are being more broadly adopted to facilitate rapid new product development and organisational change. Cockburn and Highsmith (2001) had observed that agile development focuses on the talents and skills of individuals, moulding processes to specific people and teams. This draws attention to the interplay between team member identification and accessible talent within and external to an enterprise, seen as an aspect of enterprise agility (Nijssen and Paauwe, 2012).

These two trends: the digitalisation of business and the need for enterprise agility are leading to human resources management becoming more competency-oriented rather than job-oriented, impacting the nature of different kinds of supporting information systems. Whilst personnel competency mapping is not new, there is an increasing need to identify both current and emergent gaps (Kaur and Kumar, 2013)

and the interaction between competencies in a transdisciplinary operating environment. However, there is some variety in IS approaches to support such mapping, and in this paper, we report on observations from a literature survey exploring the topic. The paper contributes to the literature by suggesting the application of hierarchical competency interaction matrices in developing mapping tools.

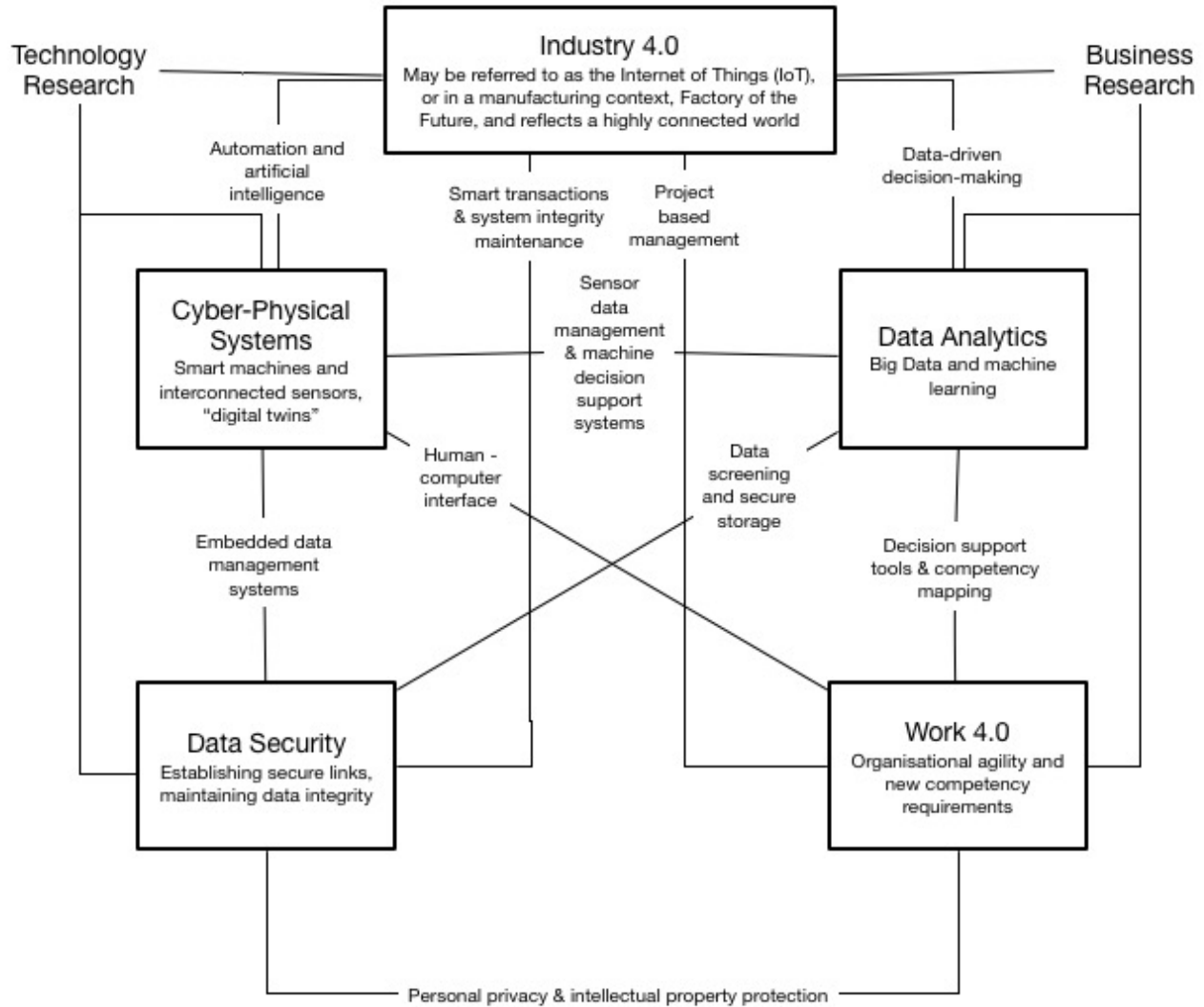


Figure 1 A representation of the elements of ‘Industry 4.0’

COMPETENCY MAPPING AND EVOLVING COMPETENCY REQUIREMENTS

Thirty-nine academic articles identified using the keyword competency combined with other terms like industry 4.0, work 4.0, agile and digital transformation were stored in the EagleFiler application which facilitates clustering associated references into folders, adding associated notes and tags (which can be organized in a hierarchy) and conducting text searches across the whole set or within a folder or tagged subset. This supported the identification of seven themes, which are described below.

A number of researchers (e.g. Rezgui et al, 2012) have reviewed competency modelling initiatives in the context of related information systems tool development. Some variety in the definition of competency, variety in efforts to establish competency meta-standards, and in representative ontologies has been noted. In the following subsections we present some concepts identified from our literature survey with some illustrative instances from the literature. We use the term competency to represent the combination of knowledge, skills and attributes we bring together to get tasks done and the term competence to represent how well we might be able to perform such tasks.

Theme 1: the concept of competency sets.

In a study of building information modelling system utilization, Succar et al (2013) introduced the concept of competency sets: collections of specific kinds of individual competencies. A core set provided a foundation for a variety of activities, another set was associated with the activity domain (in their case, building design), and a third set was designated as execution competencies (generally linked to knowledge of IT tools used). 24 sub-tier competence elements (each of which had a brief description) identified in this case were viewed as a Business Information Modelling inventory of competencies to be acquired, assessed and applied.

Theme 2: introducing matters of relative proficiency.

Consistent with broad industry practice, Succar et al (2013) drew on the concept of levels of proficiency associated with each competency, adopting the following definitions:

- Level 0 (none) denotes a lack of competence in a specific area or topic;
- Level 1 (basic) denotes an understanding of fundamentals and some initial practical application;
- Level 2 (intermediate) denotes a solid conceptual understanding and some practical application;
- Level 3 (advanced) denotes significant conceptual knowledge and practical experience in performing a competency to a consistently high standard; and
- Level 4 (expert) denotes extensive knowledge, refined skill and prolonged experience in performing a defined competency at the highest standard.

Theme 3: Different roles require a different mix of competency sets.

Takey and Carvalho (2015) undertook a study of engineering project management competencies in a case study firm. They identified four competence categories, each of which had many components: project management processes, personal capabilities, technical capabilities and context/business understandings. 75 employees provided a self-assessment of competencies needed in their respective roles, choosing from a list of 55 candidate topics. As might be expected, some roles had an emphasis on process/technical competencies (e.g. expert consultant, coach) and some on personal competencies (e.g. consortium facilitation), but the point to be made here is that sets of competencies were required, with different combinations for different roles.

Theme 4: new requisite competencies and competency sets emerge over time.

Prifti et al (2017) undertook a combined literature review and focus group study of new and traditional competencies required in this environment. They considered transdisciplinary information system, computer science and engineering competencies. The most commonly mentioned competency sets were firstly, communicating with people, secondly technology affinity /big data / problem-solving, and thirdly life-long learning / working in interdisciplinary environments. Eight generic competency sets with a total of 20 sub-tier competency dimensions were identified. Some dimensions showed computer science - engineering overlaps and some showed computer science - information systems overlap. Thirdly, more than 6000 individual behaviours were identified at a lower level again, and these were clustered into 112 sets.

Theme 5: new requisite competencies are not just associated with new technologies.

Sherehiy et al (2007) characterized three attributes of an agile workforce. Proactivity was seen as a capability to anticipate a problem related to change, to offer solutions and take personal initiatives.

Adaptivity was mentioned in terms of interpersonal and cultural adaptability, spontaneous collaboration, learning new tasks and responsibilities, and professional flexibility. Resilience as seen to embody a positive attitude to change, to new ideas and new technology; a tolerance of an uncertain or unexpected situation and coping with stress. From a study of 136 IS projects in a global firm, Fisk et al (2010) showed that boundary-spanning roles positively influenced success. The characterized such roles as ambassador, coordinator and scout, Enactment of these roles helped provide access to business, technical and business information systems competence sets within and external to the team. Successful teams could accumulate experience related to language usage, business network connections, business contacts and cross-organizational activities (described as an acculturation process).

Theme 6: competency modelling as a management tool is not just about Information Systems.

Campion et al (2011) reported on the findings of an industry/academia task force on best practice in competency modelling facilitated by the Society for Industrial and Organisational Psychology. Industry practitioners saw the shift from a focus on job descriptions to a focus on competency as an innovation. A strategic management view of a competency model as a collection of knowledge, skills, abilities and other characteristics was taken, and favored over job analysis for a number of reasons. For example, a finite number of competencies could be applied across many job families, future job requirements could also be readily identified, and the same attributes could be utilized in many HR systems like hiring, career development, learning/training and compensation systems. Twenty management ‘Best Practices’ related to analyzing, organizing and utilizing competency information were identified, including using competency libraries and identifying an appropriate level of granularity (number of competencies, level of detail). Those that characterized operational excellence, personal effectiveness and exceptional talent in the realization of organizational goals and strategies were discussed, introducing matters of context. It was noted that competencies had to be maintained over time, and it was important to recognize the role of IS as a tool, not the system.

Theme 7: supporting IS tools have proven useful in specific contexts, but generic representations are still evolving.

Given that competence model components can be associated with sets of competencies, each having associated knowledge, skill and other attributes, a number of IS initiatives have pursued the idea of an underlying generic ontology (e.g. Miranda et al, 2017). At finer levels of granularity, a distinction is made between the ability to do something (skill) and the information to support this ability (knowledge). Christiaens et al (2006) had noted that mapping child-parent relationships may be necessary in identifying appropriate competence sets, but it is not sufficient as child-child and parent-parent relationships may exist to service particular applications. Drawing on developments in database design, they characterized a three-layer model representation as a competency repository supporting a competence repository (a set of competency ‘commitments’) that supported an application layer. This kind of structure seems consistent with observation 4 made earlier in this paper and allows for the recognition of new knowledge set combinations needed to support Industry 4.0 work.,

CONCLUDING REMARKS

Our interpretation the foregoing observations is that there is some value in being able to map workforce competencies, that individual competency elements are combined in sets to achieve particular goals, and that in considering individual capabilities, the level of competence needs to be considered. Whilst the context of the studies presented earlier may be different, at some high level of abstraction there are generic requirements, as illustrated in Table 1. Discussion at this level that can still stimulate consideration of operational needs, e.g. what tools have to be used and what boundary spanning skills are needed to get complex work done?

We might not only need to understand a new technology and how to use it, we might have to understand how to use multiple technologies in combination. For example, referring to Figure 1, a particular project may require knowledge of some aspect of cyber-physical systems plus some aspects of data security. If work is organized as a succession of team-based projects rather than individual tasks, then assembling a group that between them have all the required competencies becomes the focus (e.g. Fisk et al, 2010), suggesting a need for matching processes that include consideration of non-technical skills. From an IS perspective, representations of a competency map like table 1 implies that generic parent-child ontologies might be developed, and this concept has provided a foundation for some specific IS implementations.

Generic Competence Set	Associated Competencies*
The ability to get work done	technical knowledge, personal skills and the use of tools
The ability to work with others	communication, leadership and boundary spanning skills
The ability to adapt to changing conditions	a pro-active, collaborative orientation, being able to learn fast, and a tolerance of uncertainty

*The competencies shown as **bold** receive special emphasis in a work 4.0 / agile environment, and each item listed will have sub-tier components

Table 1 A representation of Requisite Competence Model Components and Associated Competency Sets

Our extension to competency mapping theory suggests that that interactions between the ontological components also need to be considered using relationship matrices, particularly when new technological knowledge is involved. For example, taking the ten kinds of object shown in the table 1 competencies column and mapping them against each other might highlight a need to consider boundary spanning skills in relation to technical knowledge. In addition, when considering a particular role, requisite competency sets can be identified, e.g. technical skills combined with communication skills. While the diagonal of a relationship matrix is normally considered null, this gives a pathway to explore subsidiary matrices (e.g. the technical knowledge / technical knowledge connections may stimulate elaboration of project – specific knowledge needs). And within a knowledge domain a similar matrix may show particular specialisations (e.g. software development may require knowledge of particular programming languages). This leads to a hierarchy of matrices that provide a means of mapping hundreds or thousands of micro-level observed in the discussion of themes 3 and 4. Some researchers have differentiated micro level competencies by describing them as attributes or behaviours. The competency relationship matrix concept combined with standardized ways of representing entities (e.g. IEEE Std 1484.20.1TM-2007) is to be a subject for further research.

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