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TOWARD A NEW MODEL OF COMPETENCES IN WORK SITUATIONS

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Abstract: Over the last 15 years, and in a context of globalisation competence management has become an essential lever of competitiveness in companies, and an essential factor in industrial processes' performance. However, competences management requires relevant modelling of competence, given its complex nature and the evolution of the company's activities. In this paper, we propose an activity-based model of competence to represent competences mobilized during an activity. A specification of terminology is first defined around the concept of competence, and then we define its different characteristics. Finally, after a study of the main models proposed in the field of industrial engineering, we present an activity-based model of competence.

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Keywords: competence modelling, competence characteristics, individual competences, human resource management.

1. INTRODUCTION

The industrial environment is constantly changing due to socio-economic changes, leading to the fourth industrial revolution. This revolution organizes production processes induced by innovations related to Internet technologies, as cyber-physical systems (CPS), the Internet of Things (IoT), the Internet of Services (IoS), and several technologies requiring several competence profiles (Hecklau *et al.*, 2016). The major challenges of this revolution are therefore not only technological, but are also related to human capital. In industry 4.0, the human operator is confronted with the increasing complexity of his daily tasks which are less and less repetitive and require ongoing competences development. Competences are therefore seen as an added value that is needed to sustain the competitiveness of organizations in the future (Graczyk-Kucharska *et al.*, 2018).

Our research aims to define what should a model of competence include to describe as well as possible competences mobilized across an activity. This paper lists firstly the main characteristics of a competence. Several existing models are then analyzed in view of these characteristics. This led us to propose a new model for a dynamic representation of competences in work situations.

2. COMPETENCE CHARACTERISTICS

The concept of competence has evolved considerably since the 1990s. The definitions proposed so far do not make it possible to extract a common perception of what a competence is. As Winterton noted, "it is impossible [...] to arrive at a definition capable of accommodating and reconciling all the different

ways that the term is used" (Le Deist and Winterton, 2005). Adding to that, it has been noticed that there are two terms in English syntax which have different meanings for designing the abilities that lead to effective job performance: competence and competency. McClelland was the first who introduced in 1973 the term of "competence" defining it as "personal habits that lead to more effective or superior job performance" (Fikri Benbrahim *et al.*, 2018). While he went on to describe the individual characteristics underlying superior performance as "competency". Competency assessment methodology was then introduced by McClelland in a consulting firm that became Hay McBer (Kou, Jia and Wang, 2013).

Competency indicates the causal relationship between the individual characteristics inherent in a superior performer and his/her successful and effective job performance. In contrast, competence highlights the link between a complex set of knowledge, skills and motivations, behaviors, etc. and a job-fit within a specific work context (Boumane *et al.*, 2006; Belkadi *et al.*, 2007; Miranda *et al.*, 2017). In short and as shown in Fig.1, competence means what people can do and



Fig. 1. Competence and Competency (Sanghi, 2007)

competency means how they do it (Sanghi, 2007).

Another confusion was noticed across our research concerning the term "skill" that is often confused with competence for

their tight link. For the rest of the paper, the term “*skill*” concerns a specific attitude for a task, sport, etc., the ability acquired through training and/or practice of activities (Le Deist and Winterton, 2005; Durand, 2006).

Considering that our work is more focused on what people can do, we will be using competence terminology for the rest of the paper.

The literature research conducted across the competence concept permit to identify three categories of competence:

- **Individual competence:** What is mobilized by the individual to perform an activity in a specific situation (Koeppen *et al.*, 2008).
- **Collectif competence:** Obtained by the quality of interaction between individuals and not only simple additions of their competences. Collective competence is relying on two complementary parts, one referring to the individual and the other to the organization. A simple variation in one of these parts modifies the collective competence itself (Macke *et al.*, 2013).
- **Organizational competence:** Organizational competence involves coordinating work with other institutional divisions and with external entities. These competences enable to optimize the use of available resources, setting short- and long-term objectives, and developing strategies and policies to achieve these objectives (Da Silva *et al.*, 2013).

The axis of our research concern the individual at the core of his/her activity, therefore, we are focusing on individual competences.

Human competence is a function of exceptional performances, in other words, competent people are those who can create valuable outcomes without excessively costly behaviour (Gilbert, 1996; Teodorescu, 2006). Nevertheless, it is important to clarify the link between the two concepts of competence and performance, by answering to the following questions:

- Is it possible to be competent without being performant?
- Is it possible to be performant without being competent?

A good number of authors argued that competence as an abstract concept is a social recognition that values effective and efficient human behaviour (Belkadi, Bonjour and Dulmet, 2009; Nagels, 2009; Kolibáčová, 2014; Miranda *et al.*, 2017). In other terms, competence is an appreciation of the performance. It can therefore be said that a person qualified as competent must be performant. On the other side, being performant does not always imply that a person is competent. Performance leads to competence when it respects these conditions of effectiveness, reproducibility, and regularity (Nagels, 2009). Only one performance is not sufficient to consider the individual to be competent, chance can also explain performance in a given context. This implies that there is a mismatch between performance and competence. (Jonnaert *et al.*, 2006). In other words, performance is a value

with a short-term effect, while competence is a value with a medium- or long-term effect, which requires reproducibility of performance.

In this paper, we consider that a competent person is by nature performant, but the opposite is not always correct.

Across our literature research on individual competences, we were able to identify ten fundamental characteristics.

- **Action/Activity:** Competence is constructed in action, and can not function "in a vacuum" (Miranda *et al.*, 2017).

- **Finality:** Competence is exercised to be achieved. To be competent implies having demonstrated an ability to do and possess the knowledge to achieve a goal to be reached (Boumane *et al.*, 2006; Kou *et al.*, 2013; Miranda *et al.*, 2017).

- **Contingency:** Individual competence is highly contingent on a given work situation and therefore corresponds to a context. Indeed, people who possess knowledge or skills may not be able to mobilize them in a relevant way in a work situation. Therefore, it is the situation that reveals the actual competences held by the individual (Boumane *et al.*, 2006; Koeppen *et al.*, 2008).

- **Cognitive:** Competence is based on a set of knowledge, skill, and attitude (Boumane *et al.*, 2006; Durand, 2006; Kou *et al.*, 2013).

- **Regularity:** Competence presupposes regularity and reliability in its exercise. To do this, competence requires permanent renewal, which requires maintenance so as not to be exhausted. Its exercise is then necessary for it to be maintained (Ley and Albert, 2003).

- **Performance:** Competence is strongly linked to the employee's ability to effectively achieve the objectives assigned to him/her in his/her functions (Koeppen *et al.*, 2008; Miranda *et al.*, 2017)

- **Visibility and recognition:** Competence must be recognized by others to gain credibility (Boumane *et al.*, 2006)

- **Dynamic and cumulative:** Competence is in perpetual renewal. This renewal must be a cumulative aspect and not a renewal by destroying the previous competence. Consequently, individual competence is acquired and transmitted through learning and training processes. It is the bearer of the learning dynamic (Durand, 2006).

- **Combinatorial:** Competence is a combination of knowledge, skills, and attitudes. Competence is composed of elements that interact dynamically with each other and combine them. (Boumane *et al.*, 2006).

- **Process aspect:** Competence is a process where personal and environmental resources are permanently adapted to the different variations of the mobilization context. This dynamic implies a permanent construction and enrichment of these competences (Harzallah *et al.*, 2002; Ley and Albert, 2003; Boumane *et al.*, 2006).

Given the identified characteristics, we define individual competence as a **process of combining and mobilizing complex elements (personal resources & environmental resources) to carry out an activity under a SMART**

(specific, measurable, acceptable, realistic, and time-bound) objective. Regarding this definition:

- **Personal resources** correspond to the possessed knowledge, skills, and attitudes combined and mobilized by an actor to accomplish a task or activity.
- **Environmental resources** refer to a set of elements (human, financial, time, material, etc.,) mobilized to accomplish a task or activity.

As competence is defined, it now appears as a complex and composite concept, with very varied characteristics. Considering this complexity, it seems clearer that it is important to have a representative model for this concept.

3. COMPETENCE MODELS

Competence modelling has seen relatively few research works in the last two decades. In the field of industrial engineering, five main models can be distinguished: the CRAI model, the s-a-r-C model, the systemic model of competencies, the ARISTOTELE model, and the COMBA model. Each model brings its vision of the characteristics of competence to be described.

To better visualize the contributions of each of these models, **Table 1** presents a comparison based on the competence characteristics identified above. This comparison shows that three main characteristics of competence (Performance, Dynamic & Cumulative, and Process aspect) are not well considered in the existing models.

Unlike the other four models, the systemic model takes into account all the characteristics. However, the construction of competence in this model is based on a declarative aspect centered on the notion of required competences for a given

activity. The actor is led to describe the competences required to carry out the activity. However, within an activity, some competences can be developed and mobilized to respond to an unforeseen situation that was not taken into account when defining the required competences.

We consider that it is relevant to go beyond the declarative aspect concerning individual competences to represent the competences effectively mobilized. This brings us to reflect on a model of competence for the identification of the competences effectively mobilized during an activity.

4. TOWARD A NEW COMPETENCE MODEL

We tend to contribute to the formalization of the polymorphous and extremely complex nature of competence across the modelling of effective competences mobilized during an activity. The competence can not be represented by a simple box given its complexity. *Fig. 2* presents a dynamic sight of how competence is constructed/deployed over time. The competence in this model is mobilized through the activity and is built in a scheme process mobilizing & combining environmental and personal resources. The model is based on 7 concepts, five of them are already defined in section 2 (competence characteristics): Personal resources; Environmental resources; Activity; Context, and performance. In the following, we define the remaining concepts: Objective; Scheme;

Objective: Designates the aim of the activity(ies). It must be specific, measurable, attainable, achievable, and time-limited (SMART).

Scheme: Activity organization consisting of four elements (Coulet, 2011).

Table 1. Comparison of five competences models

	Action Activity	Finality	Contingency	Cognitive	Regularity	Performance	Visibility & recognition	Dynamic & cumulative	Combinatorial	Process aspect
<div style="display: flex; align-items: center;"> <div style="width: 15px; height: 15px; background-color: #fff9c4; border: 1px solid black; margin-right: 5px;"></div> Explicitly integrated </div>	✓	Considered under “The achievement of missions or tasks”	Considered under the “Aspects” concept		Implicitly integrated by the Dm relationship		Implicitly thought evaluation of individual entity			
			Considered under “Situation”							
			Considered under “Professional situation & achievement criteria			For recognition purposes only	Through performance evaluation	Implicitly integrated by the concept of the scheme		Implicitly under scheme concept
							Under the concept of “Evidence of acquisition”	Apprehended across the link with the learning experience model (LEM)		
						Apprehended as a contextualization of competence under “Required standard”	Might be apprehended with the concept of “Evidence”			

- Operative invariants: Represents what the actor holds to be true (in-act theorem), e.g. $[Card(A \cup B) = Card(A) + Card(B) \text{ as long as } A \cap B = \emptyset]$. And what the actor holds to be relevant (in-act concepts), i.e. the sky is blue / the cathedral is symmetrical.
- Inference: Covers the information gathering, calculations, and controls allowing the adjustment of the scheme to the situation variables.
- Action rules: Effective components that generate a sequence of actions leading to the desired result.
- Anticipated results: The aim of the mobilization of the scheme.

Compared to the previous models, our model tends to represent the dynamics of competence, as well as the competences effectively mobilized (acquired or required).

The model starts from an **objective** defined as Specific, Measurable, Attainable, Achievable, Realistic, and Time-limited. This specification of the objective tends to provide a formal and structured framework for understanding the expected results and resulting activities. An example of a SMART objective is: "Simulate the energy performance of at least 50% of the buildings for project "X" within the next 04 months". Once the objective has been defined, it gives rise to a set of **activities** to be carried out. Each of these activities is intended to meet a very specific need, to contribute to the achievement of the initial objective. Considering the objective given as an example, we can define the following three activities:

- Activity 1: "Modelling of buildings" / Expected result: "digital models for at least 50% of the buildings reproducing the architectural plan and respecting all the defined measures".
- Activity 2: "Energy simulation" / Expected result: "Rate of heat loss and energy demand over the 4 seasons".
- Activity 3: "Report writing" / Expected result: "A document including the results of the energy study of at least 50% of the buildings".

Each of these activities is carried out by an actor according to his **scheme**. The scheme is guided by the **activity requirements** (e.g. activity procedures, specifications, technical standards, etc.) for the mobilization of **environmental and personal resources**. For example, in carrying out Activity 1, the actor executes a sequence of actions, e.g., reproduction of the plan in 2d, the transition to 3d design, and materials definition. Across these actions, he mobilizes, on one hand, his knowledge (e.g. reading an architectural drawing), skills (e.g. designing from a technical plan), and aptitudes (e.g. rigor and autonomy at work). And on the other hand, he mobilizes software resources (e.g. Design-Builder™, Adobe Reader™) and working time. At the end of the scheme, we check if the activity is carried out, which brings us to two possible cases.

In the first case, the activity is fully realized with **actual results** (e.g. 60% of all buildings are modeled). These results

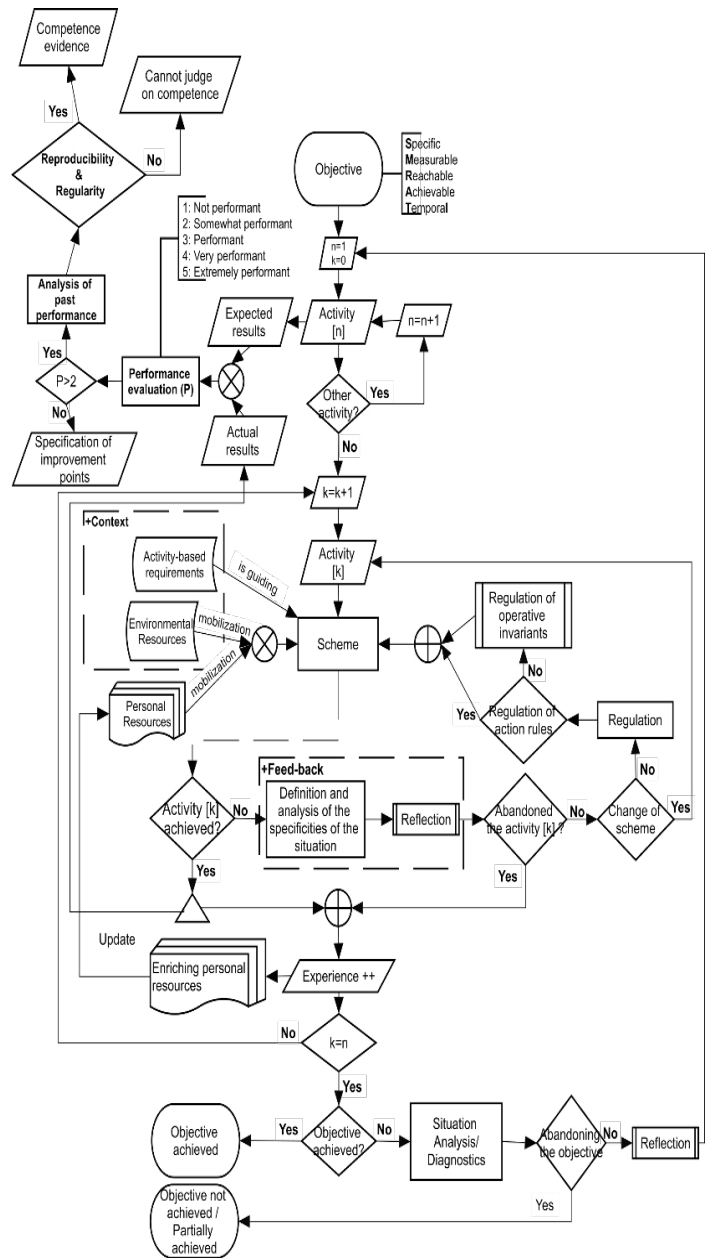


Fig. 2. Activity-based model of competence

are then used to evaluate the **performance** according to the expected results, for example :

- Less than 30% of buildings are modeled = Not performant
- Between 30% and 50% of the buildings are modeled = Somewhat performant
- 50% of the buildings are modeled = Performant
- Between 50% and 80% of the buildings are modeled = Very performant
- More than 80% of the buildings are modeled = Extremely performant

Depending on the performance (see Fig. 2), we either have an **improvement specification**, or a process of **analysis of the past performance**. In the first situation, performance is below the threshold of acceptability (e.g. improved management of working time, envisaged training for mastering CAD software,

etc.). In the second situation the process aims to denote if this performance has been **regularly reproduced** under other contexts. If it is the case, this performance is considered as an evidence of competence (e.g. in the use of CAD software, design from a technical drawing, etc.) (Jonnaert *et al.*, 2006; Nagels, 2009). Otherwise, **no judgment can be given on competence**.

For the second case, the activity is carried out only partially or not at all. In this case, a process is launched including the **definition and analysis** of the specificities of the work situation (context), to identify potential causes. In the case of Activity 1, this analysis may indicate for example, that some quotations are not included in the initial plan, or the volumes have high geometrical complexity. The results of this process lead to a sub-process of **reflection** that will help determine whether or not the activity will be **abandoned**. If we continue the activity, we must either modify the current scheme or **regulate** it to overcome the constraints related to work situations. For example, during Activity 1, if some quotations are missing from the initial document, the scheme will be regulated to add an action of "manual completion of missing quotations" in the action rules.

At the end of the activity, whether it is carried out or not, we have an acquired **experience** allowing to enrich the personal resources of the actor. For example, skills concerning the design of complex geometry, or knowledge related to the use of CAD software (e.g. keyboard shortcuts).

At the end of the execution of all activities, we check if the **objective is achieved**. If this is not the case, a process of **analysis and diagnosis** of the work situation is carried out to determine if the objective is still attainable. If this is the case, a sub-process of **reflection** is launched to redefine the activities according to the current work situation. This analysis can show, for example, that in 20% of the modeled buildings, the calculation of thermal losses/gains in winter/summer has not been carried out. One of the reasons would be, for example, a lack of data on the types of insulation materials or concrete used (e.g. reinforced concrete, high-performance concrete, etc.). The reflection made thereafter will redefine the activities to include :

- Exchange with the design office for completion of data on the materials used.

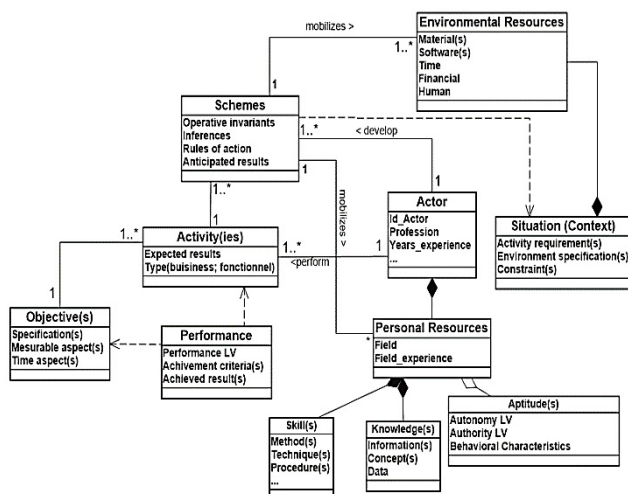


Fig. 3. Mobilized competence instance

- The finalization of the digital mock-ups.

Fig. 3 represents a static sight of the mobilized competence (in UML language) for an easier understanding and better exploitation of the proposed model (Fig.). The competence mobilized by the actor is identified in relation to the activity carried out, the performance observed and judged, and the context of the application.

The choice of process flow diagram modelling for our model (Fig. 2) tends to reflect the process aspect of competence. The competence is constructed across a process of perception and interpretation of the ongoing situation. This process aims to select, combine, and mobilize the personal and environmental resources needed for carrying out the activity. The scheme as part of this process permits the selection and construction of the relevant combination of actions carried out during the activity. The experience acquired from the process of regulation ensures the renewal of the competence, its maintenance, and its evolution so that it is not exhausted. The finality for mobilizing a competence is represented by the expected results extracted from the initial objective. This competence is indicated by an acknowledged performance serving at the same time as evidence and recognition of it. The loop regrouping the processes of analysis, reflection, and regulation of the scheme around the specificity of the situation represents the dynamics of adaptation to context variations. A similar activity context allows to consolidate the acquired competences and to improve their level of maturity. However, a new context represents a richer learning opportunity and allows the development of new schemes and the acquisition of new competences. The performance evaluation is used as proof of the mobilized competences. Through this analysis, we can observe that all the characteristics of competence are considered by the activity-based model of competence.

- The cognitive & combinatorial characteristics are apprehended through thought scheme process.
- The performance, finality, and visibility & recognition characteristics are apprehended through the performance evaluation process.
- The regularity characteristic is reflected in the personal resources update loop.
- The contingency is represented by the notion of context.
- The dynamic & cumulative characteristics are apprehended through the processes of analysis, reflection, and regulation of the scheme.

5. CONCLUSION & PERSPECTIVES

The competence characteristics identified across this work contribute to the clarification of the individual competence concept. The analysis of the existing competence models has shown that some characteristics such as performance, process aspect, and dynamics are not fully integrated. Judging that a competence model must bring together all these characteristics, we proposed an activity-based model of competence to contribute to the modelling of individual competences. The

proposed model is axed on the notion of mobilized competences for an activity. This model makes it possible to apprehend all the characteristics of competence through an activity-centred vision to represent the competences effectively mobilized.

The perspectives of this work are articulated around two axes:

- Operationalization of the model to provide a proof of concept on the identification of competences based on activity traces.
- Construction of effective competence cartography for a better representation of the competences available in an organization.

This work is part of the ANR project on the Capture of Operational Traces of the Company's actors to build Human Capital and define winning Processes (CatCap).

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