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An Action-based Model to Identify Human Competencies through the Trace of Actions: Case of a Building Energy Engineering Company

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Abstract: The digital transformation of organizations, in the era of Industry 4.0, has profoundly renewed industrial work including design, production and distribution. With such an evolution, actors would learn a lot and redefine many formal (operating methods, procedures, processes, methods) and informal (corrections/remedies, local regulations, skills, etc.) working practices. Competencies are at the heart of these learnings and practices. Sociologists, psychologists, ergonomists and engineers have tried to define and characterize “competency” for its better identification and evaluation. Most of these researchers agree that competencies are difficult to identify but could be determined by inferring them through observation and traceability of human actions – those being more or less representative of reality. However, this identification process requires upstream relevant competency modeling in order to better interpret the collected competencies’ traces and then confront them with peers to access the judgment on competencies. The authors of this paper rely on a presentation of concepts from different disciplines to define competency, emphasize its link to action and propose an action-based competency model. An example observed in a Company is detailed to validate the proposed model. At the end of the paper, we identify six situational mechanisms of articulation between material, immaterial and the actor’s personal resources, necessary for competencies deployment and construction.

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Keywords: Competency modeling, action, trace, industry 4.0, human-centered organization.

1. INTRODUCTION

The fourth industrial revolution focused mainly on processes’ digitization and the use of artificial intelligence, which are deployed, inter alia, to increase productivity and efficiency, relegating among its priorities the role of workers involved in the production model. However, since 2016, we perceive the emergence of a fifth revolution that is more human-centered. Instead of asking what we could do with new technologies, we should be asking what technology could do for us. It is about creating 4.0 organizations aligned with existing human capital instead of adapting humans to exponentially growing technologies. Thus, a first step towards a human-centered model is to identify what human resources are capable of doing in interaction with a technological environment to perform their work, i.e. identify their competencies. It is also important to define what learning processes these organizations must adopt to ensure an alignment between human and digital.

However, to do this, the tools and methods traditionally used by managers are not adapted and are now outdated in the context of recent industrial revolutions. Researchers and practitioners argue that traditional competencies repositories, for instance, do not meet the new fifth industrial revolution’s challenges (Mlaouhi et al., 2021; Paschek et al., 2019). Indeed, these referentials do not consider the context, nor the resources mobilized in which competencies are deployed (Mayen et al., 2010). In fact, nowadays, HR managers identify competencies via declaration or assessment tests. However, firms have to rethink their professional practices and search for new

methods to efficiently manage their human capital, as well as access to real competencies deployed by professionals in the face of 4.0 changes.

Our research aims to extract these competencies encompassed in current practices and learnings in order to: (1) manage the intellectual capital of a company by developing or integrating new ones, and (2) intelligently mobilize the professionals’ competencies by defining suitable practices.

The problem that arises in front of such objectives lies in the difficulty of identifying a large number of competencies that escape standardization and which would be at the heart of the regulatory needs of 4.0 organizations (agility, resilience, corrections, detection of weak signals, etc.). For this purpose, we intend to propose a method allowing competencies inference through the analysis of their traces captured by the observation of human actions and we focus in the action situation on individual (learning from self-experience) and collective (learning in situation, transmission, correction) learning practices.

Admittedly, researchers propose to stop using the classical and declarative methods of competency management (Mayen et al., 2010), but as far as we are aware, no one has yet adopted the method of competency identification that we propose in a context like the present.

The work presented in this paper is the first step to reach the above-mentioned goals. It is about defining the concept of “competency” and understanding how competencies are constructed and deployed by professionals, in order to infer

them in the most possible objective way. This paper therefore aims to model the processes of construction and deployment of individual competencies. It is composed of five sections. Section 2 is dedicated to the competency concept (definition, relationship with action and literature review on competency models). Section 3 presents our action-based model of competencies' traces. An example of a real situation, observed within a company, is developed in section 4 to validate our model. Finally, in section 5, we conclude the paper with results and discuss future developments.

2. COMPETENCY CONCEPT

In order to model the processes of construction and deployment of individual competencies, it is necessary in first place to understand the concept of competency (section 2.1) and its relationship with action (section 2.2) and to discuss models of competency proposed in literature (section 2.4).

2.1 Competency definition

The variety of scientific fields (psychology, sociology, ergonomics, management science, education sciences, engineering science especially industrial engineering and computer science...) involved in competency's studies makes difficult retrieving a single definition for the concept. Indeed, (Le Deist & Winterton, 2005) and (Loufrani-Fedida, 2006) point out that it is impossible to identify a coherent theory or to reach a definition capable of reconciling all the different ways in which the concept is used. The purpose of this paper is not to exhibit all competency definitions. Rather, we intend to grasp the major issues of this concept that make consensus and to identify the links that researchers establish between competency and efficiency at work. Although a good number of interpretations exist in different scientific fields, they all call upon three fundamental elements: "context / situation", "activity / action" and "result / performance". We put each pair of terms together without making any distinction given their similarity or the link between them found in the literature. To give a definition to "competency", we have coupled these three elements. Competency, hence, refers to "the ability of an individual, a work group or a company to select, combine and mobilize material and immaterial resources in a certain situation, in order to carry out a given activity or a process of action and achieve a result" (Mlaouhi et al., 2021).

2.2 Relationship between competency and action

Competency is invisible and intangible. If we paraphrase (Le Boterf, 1994)'s definition that considers competency as "a mix of knowledge, know-how and know-being which are implemented in the particular context of a work situation", we could understand that the deployment of competencies is translated with actions. Actions are the visible part of competency. More precisely, it is the actions carried out in a certain situation and the obtained result that we consider the visible part of the competency. Many studies highlight the interdependence between competency and activity or action (Suchman, 1987; Bril & Roux, 1993; Le Boterf, 1994; Clot, 1995; Leplat, 2004; Coulet, 2011). For Leplat, characterizing competency necessarily involves describing the organizing processes of activity and not limiting it to the interpretation of the situation and the result (Leplat, 2004). Therefore, the

relationship action-competency is articulated around the fact that actions are a trace of competency. We are thus against the idea that competency is an intellectual capital in the minds of professionals.

(Suchman, 1987), in her theory of "situated action", supports the idea that each action depends on the material and social circumstances in which it takes place. She also argued that "what structures an action or activity is not something that precedes it (an action plan); it is rather the immediate direct effect of the situation in which the person is". Situated action theorists, such as Suchman, have shown that any action requires a certain adjustment between the actor and the environment. This adjustment could only be effective insofar as there is an adequacy between the means used (material and/or immaterial) and the expected result (Bril & Roux, 1993). This brings us back to competency definition and gives importance to the concept of "situation/context". In other words, the couple "action-situation" supports the perpetual construction of competencies. Between action, situation and competency, there is an evolutionary dynamic: the situation is a support for action, which boosts the deployment of existing competencies, their updating, and even the construction of new ones. This use and updating of competencies and the construction of new ones bring us back to the idea defended by (Tourmen, 2015). But what is concretely adapted are patterns or "schemes", i.e. internal and cognitive structures of action that could be actively repeated and that are organized by "operating invariants" (rules, knowledge, procedures, concepts, etc. all in action) and linked to a number of "goals". However, these schemes are cognitive, partly conscious for the individuals themselves and, therefore, difficult to observe. That is why it is necessary to address the visible part of competency, i.e. actions, in order to infer professionals' competencies.

In most of the definitions found in the literature, competency has been coupled with the concept of performance. For instance, (Bonjour et al., 2002) state that competency "is the mobilization and the dynamic organization of a heterogeneous cognitive resource set leading to the production of a recognized performance, within the framework of a finalized activity ...". From such a definition, we could conclude that performance involves social judgments made by an individual or a group. These social judgements depend on numerous criteria constituting a complex filter of interpretation that varies according to individuals, organization, occupations and contexts (Foucher, 2007; Lamri, 2018). We could distinguish three forms of social judgments: by the individual himself, (the actor is self-judging), by peers, (the actor is judged by another individual or a group of individuals) and by the hierarchy, (the actor is judged by his manager/s). All these forms of judgment are built on collective criteria explicitly or implicitly founded. We could also distinguish two types of social judgment according to the framework in which it is carried out: spontaneous judgment, where individuals have not been explicitly asked to judge, and initiated judgment, made following a manager's request (Bonjour et al., 2002; Lamri, 2018). The process of evaluating and judging results reflects the dynamic part of competency. Indeed, it is thanks to social judgment –in all its forms– that the professional is able to

validate the schemes used or to create new ones, to adjust actions and to update his personal resources, thus, to learn, adapt actions and develop competencies (Boumane et al., 2006).

2.3 What do we mean by action trace?

As we have already mentioned, competencies are difficult to identify but could be determined by inferring them through observation and traceability of human actions. The link between action, trace and competency for the researcher or for the one who will judge lies in what is observable of the competency and the performance. The trace is what allows to establish the judgment, and deduce within organizations the capacities of an individual and therefore his assignment, or even what is required on a position.

The concept of “trace” has been originally used in the fields of archeology and history, but has been integrated in recent decades within the digital domain to refer to data created by and about individuals. It includes: voluntary data explicitly created and shared; observed data derived from the involuntary recording of activities; and inferred data based on the analysis of voluntary or/and observed data (Dulong, 2017). This concept could be extended to include data and information collected without the use of a digital tool or system (Hulin, 2010). This is the case when an observer is mobilized to accompany and interview professionals while performing their activities or when the contents of documents and materials developed by these professionals are used. Thus, in order to collect these data, we need a theory or a model of action to know what information to collect and to expand the points of view on the activity of professionals. For instance, the minutes of a meeting is a trace of action. However, its content, the meeting that took place beforehand, the process of its writing, the other professionals involved, etc. constitute a whole that could bring us a deeper meaning (Hulin, 2010).

2.4 Competency modelling in literature

Competency modeling is quite important to frame and structure our empirical work (observation). Indeed, it is necessary to apprehend the process of deployment and development of competencies at an individual level. Before developing our model of competency, we have studied models proposed in the literature and particularly those embracing items discussed in section 2.1, including the three fundamental concepts: situation, action and performance.

Theorizations of the interdependence between competency and action-situation are rather descriptive. Formalized representations are competency models such as the systemic competency model (Boumane et al., 2006), the dynamic analysis model for the description and the evaluation of competency (Coulet, 2011), scheme activation model (Bonjour et al., 2002) and the interaction process model (Belkadi et al., 2005). Nevertheless, these models were elaborated for purposes other than identifying competency through traces of human actions and interactions or were used as part of a declarative approach of competencies identification. We consider that these models are complementary. Some of them do not represent the

construction process of the resource environment (selection, combination and mobilization) and others do not model or model in a limited way the adaptive aspect of competency. Therefore, from the perspective of inferring competencies from the observation of professionals' actions and interactions, we rely on the common and complementary components of these models, as well as other elements that are found in them but found in the literature.

3. AN ACTION-BASED COMPETENCY MODEL

We choose to use BPMN (Business Process Management and Notation) to model the deployment and construction of competency in action. Indeed, we wish to highlight the process aspect of competency. It is, in fact, a process of combination and mobilization, always in adaptation, of different types of resources with a dynamic of construction of new competencies and enrichment of those deployed.

For our action-based model, we drew inspiration from (Norman, 1986)'s theory of action and (Suchman, 1987)'s situated action theory, as well as other works on the relationship between competency and action and on objects in action (Conein et al., 1993). We have also based our researches on the work of (Leplat, 2004) and (Coulet, 2011) to model the dynamic nature of the competency residing in the loops of activity regulation. In what follows, we will explain our action-based model in order to describe the process of deploying and developing competency. We have developed our action-based competency model (see Figure 1) in a mode of problem solving and confrontation of the situation's uncertainties. In fact, the theory of action stipulates that the actor is constantly subjected to problems and hazards and that he must act and deploy his competencies in order to overcome them (Suchman, 1987; Dewey, 1993).

The actor has a task to accomplish, an objective (4). To do so, he has experience, knowledge, know-how and protocols (16) that he gained from previous practices and interactions with his professional and personal environment (15). He assesses the situation and carries out a routine activity until a singular event (1) disrupts the continuity of the situation. After perceiving the signal (2), the actor starts searching for this continuity. He enters in a process of inquiry (3). This process allows the actor to question and develop his knowledge, in a sense of facing the disrupting event, rethinking the situation and putting new actions to the test. For (Dewey, 1993), this process consist in redefining the objective and the action plan (4&5) in order to find the continuity of the situation. Dewey underlines to what point the inquiry process supposes an interruption of the experience course. However, this interruption must be perceived as a vital and inescapable problem (Dewey, 1993; Boutet, 2016; Thiévenaz, 2019). Thus, competency is already expressed in the detection and perception of the singular disturbing event. To perform his task, the actor uses his perceptual capacities to observe the elements of his general environment, as well as the framework of his activity, i.e. the situation (14). Indeed, being competent means sometimes to have built upstream vigilance and detection capabilities, for example, freeing oneself from certain constraints to remain alerted. The actor then compares

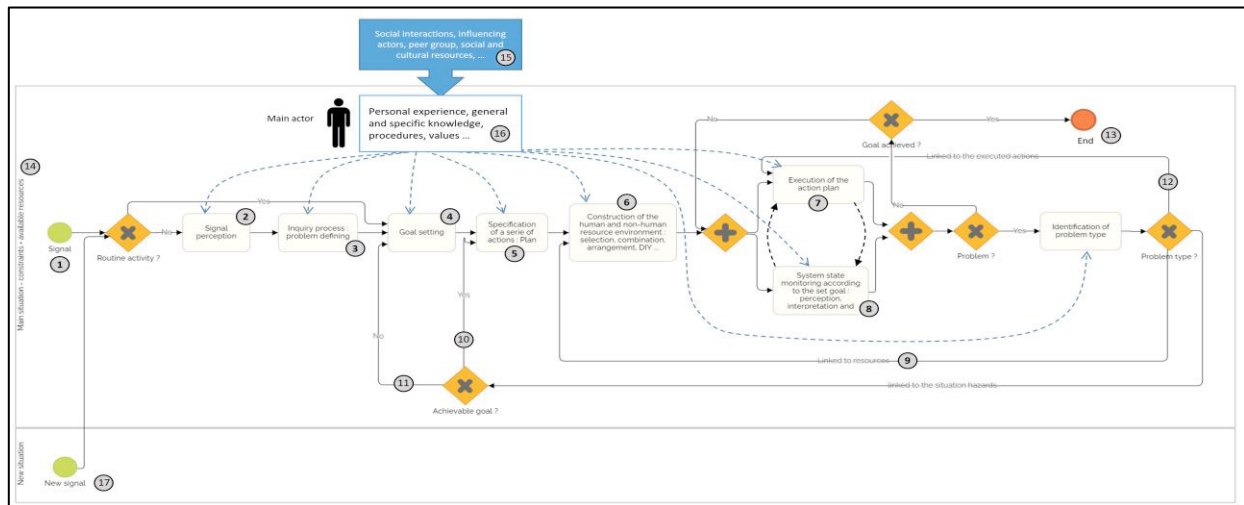


Figure 1. An action-based competency model

the present situation with previous experiences to identify similar or a close situations containing similar elements, for example, the same type of tool to use, the same type of need, etc. (scheme's principle) (Coulet, 2011). He chooses among the elements of the environment, those that are useful for the achievement of his goal. In case the actor finds himself in a completely new situation, he tries to acquire and generate new knowledge thanks to the fragmentary knowledge that he already has. He may proceed through interactions with the external environment, using for instance simulation tools, social interactions or exchanges of information and knowledge with colleagues (the actor here is learning while experimenting) (Belkadi, 2006). This first step in the process of action and deployment of competency is referred in (Belkadi et al., 2005) by the identification of the situation (3&4). Once the situation is re-assessed and re-qualified, the actor mentally prepares and redefines an action plan (5) that could be applied in the current particular situation and this, according to his personal cognitive resources and the environment resources at his disposal, as well as the constraints of the situation. Thus, the actor proceeds before the execution of his action plan to the construction-in-action of the human and non-human resource environment (6) i.e. selecting, assembling, making available and even tinkering the means, supports and tools to be used. While executing the action plan (7), the actor simultaneously controls the system (8), on which he is acting. This could make him: adjust the construction of the resource environment (9) in case of a problem related to the used resources; or adjust the action plan (10) (Suchman, 1987) when there is a problem related to situation's hazards but the initial goal is still achievable; or change the goal (11) in the case of a problem linked to the situation's hazards and a non-achievable initial goal. Moreover, it is sometimes possible as the activity progresses that the actor repeats or corrects his current action (12) until reaching an acceptable level of correlation between the results of his actions and the goal and in the end achieving the situation's goal (13). Figure 1 shows the loops of adjustments (9, 10, 11 & 12) that the actor could undertake to achieve the initial goal. These adjustments are made through different instantiations and feedback from correction and learning in action. At the end, the structure of

the action plan is stabilized and everything that the actor has experienced is apprehended so that it could be used later when encountering an identical or equivalent situation.

According to (Suchman, 1987), the situation is as much a matter of plan as of action. It depends, in addition, on what surrounds the actor with objects and environment resources. It is both a reference and an emergence. Indeed, action amounts to constantly redefining the situation according to disrupting events or new signals (17). We could switch from one reference situation to another by reinterpreting or changing the components of the situation. Besides, as we mentioned above, the notion of planning does not imply the prior determination of the action details. The progressive sequence of actions to achieve a goal is built as the immediate transformation of the environment with reference to the action plan. It is for these reasons that we have chosen to model the action plan execution simultaneously with the process of control according to the situation's initial goal.

4. COMPETENCY MODEL VALIDATION ON AN INDUSTRIAL CASE STUDY

Before presenting the example to validate our model, we would like to give a brief description of the method we followed to collect and analyze data. We do not detail this section because it will be the subject of another more elaborated paper. We have adopted a qualitative approach for our study. In fact, we seek to explore and understand how the company, specialized in building energy engineering, works and to characterize the situations and activities most revealing of competencies deployment to perform work. Our approach consists of four main steps:

Step 1: Construction of interview and observation guides following our action-based competency model.

Step 2: Collection of data on the company's employees and their activities. This first step involves collecting the most objective and concrete data possible on the company, its employees and its environment using non-participant observation and interviews.

Step 3: Data analysis, which involves organizing, classifying, sorting the unstructured collected data using the software Nvivo (<https://www.qsrinternational.com/nvivo-qualitative->

data-analysis-software), comparing them with each other, summarizing them and drawing synthesis to identify complementarities and specificities.

Step 4: Competencies inference: it consists of translating the conceptualized and finalized situations into associated competencies and then defining the combination of knowledge, know-how and qualities necessary to each work situation. To better interpret the collected traces, we confront them with peers to access the judgment on competencies.

In what follows, we present the analysis of a work situation example that we observed in the company. The goal is to run our action-based model with a real example in order to validate it. This situation consists of checking the performance of an Air Handling Unit (control flow and pressure and airflow at the outlet + energy consumption). This AHU supplies the changing rooms, which are located near the building's bicycle parking spaces. To achieve **his objective, which is to control the performance of the AHU**, the main actor defines beforehand on an Excel file the air flow rates to be checked by referring to the building plan and the studies carried out by the enterprise's engineers during the phase of design.

In the technical room where the AHU is located, the actor on his computer, connected to the building monitoring system, turns off the changing room fans to leave only the one that he has to check. Then, he adjusts the control pressure provided by the AHU, always by means of the building monitoring system, according to possible constraints of occupation, weather, season, etc. to reach the regulatory flow. This regulatory value is already established and it appears in his Excel file. Once the pressure is adjusted, he gives the signal to his teammate (here a subcontractor for the company) who measures, at the AHU, the corresponding outgoing flow, using a thermo-anemometer. The actor records in his Excel file the measures taken and dictated by the subcontractor. By carrying out this activity, the main actor perceives on the building monitoring system a malfunction in the ventilation fans of the changing rooms. This is **the first signal that redefines its objective**. There is a gap between the value given by the monitoring system and the measurement made by the subcontractor. The actor therefore decides to go measure the actual airflow rate provided by these vents. Here, we notice a whole competency that revolves around the interpretation of the reason behind the signal. When the actor decides to take the measurement in the changing room, he already has a number of exploratory hypotheses in his mind that could explain the gap between the measurement and the monitoring system value. **The actor takes with him a stepladder and an airflow-measuring cone (construction of the resource environment)**. He therefore knows for the type of ventilators installed in the locker rooms, which tool corresponds and how high he has to be to take the measurement (being one of the main designers of the building). He goes to the locker room, gets on the stepladder and positions the cone over the air vent to get the measurement. This measurement matches what is on the building monitoring system - this is not a monitoring error - but it does not meet the target. The actor measures a flow rate of about 35 m³/s while, according to the regulatory value, it should not be less than 50. The actor returns to the technical room and therefore returns to his initial objective. He found

that he is underperforming against the target. He then tries to improve it by increasing the inlet pressure by 30Pa using the building monitoring system. He checks the values on the monitoring software, goes to measure again the flow rate of the air vents in the changing rooms and puts back the initial pressure. A second problem arises: "this increase made it possible to improve the flow rate of the vents but degraded the performance of the machine", explains the actor. The mismatch between the target and the AHU's energy consumption makes him realize that the problem cannot be solved by just increasing the pressure. It is not for him to correct the malfunction but out of curiosity, the actor wanted to understand where the dysfunction comes from. When we asked him why he had chosen to increase the pressure by exactly 30Pa (why not 20 or even 40Pa), he added: "I already knew, I am basing myself on the calculation made by my Excel file and thanks to my experience, I know by how much to increase the pressure to get the right airflow". Unable to correct the malfunction, the next step to be undertaken by the actor is to write a report that lists the malfunctions and the various actions carried out during his activity, so that the company responsible for the AHU installation could put in place an action plan and correct defects. We have noticed that as long as we are in the normal or **routine activity**, the actor lets the subcontractor take charge. Whereas when a problem arises, he handles it and takes action.

5. CONCLUSIONS

The evaluation of our action-based competency model through its instantiation on a real example demonstrates the possibility to model competencies and infer them from traces of action, but it also showed the complexity of the concept. Although our model considers many of the competency characteristics identified across this research paper (contingent, finalized, involves performance, dynamic, combinatorial, process, cognitive) and covers some of the gaps in the studied models (section 2.4), it remains a simplified representation of reality. In fact, it was difficult for us to determine beforehand the action plan chosen by the actor to carry out his activity. Instead, we based ourselves on the course of actions while being executed and we tried to interpret signals as they were perceived by the actor. Our aim was to distinguish between actions that have been planned in advance and those that manifest adaptations and adjustments undertaken to face the situation's hazards, as well as, dealing with external signals. We also sought explanation from the actor through self-confrontation interviews (even in the course of actions) to control competencies inference and to fully apprehend the actor's actions and the observed situation. Moreover, we schematized in our model only the individual judgment of performance through the control process. However, it is possible (as is the case of another situation we observed) that another actor or a group of actors (colleague, teammate, subcontractor ...) initiates the corrections and adjustments that follow the control process.

Following our model, we were able to restructure the observed situation with all its components. This made it easy to **infer factually the acquired personal cognitive resources deployed by the actor** in order to face the situational hazards

and achieve his goal. For instance, we could deduce from the described situation: technical knowledge in ventilation systems, which allows the actor to know where, what, and how to measure and control. Besides, at this stage of our research, we were able to **identify six recurrent mechanisms of articulation and alignment of material, immaterial and actor's personal resources**. These mechanisms are mainly used in the case where the actor is faced with an unanticipated event:

1) Improvisation: Actor experiment with the resources at his disposal and recombines subsequences of routines thus discovers complicated and interesting combinations of actions that he had not previously imagined.

2) Diagnosis and detection & 3) Goals redefinition: Improvisation can only take place in the presence of these two mechanisms deployed upstream.

4) Anticipation: Actor uses anticipation either to save time or to avoid already known hazards. This mechanism takes place before the action.

5) Vigilance: This mechanism takes place during action. Synonymous of careful monitoring in order to be ready to react to any new event.

6) Evaluation: Schematized in our model, the actor continually examines the effects of his action, as well as his scope of action (e.g. know where to stop in the problem solving). → Traces teach us as well things when we question what we do not see: it is not only action but also the absence of action that informs us about competencies.

In conclusion, we could say that being competent consists in the individual's capacity, in a given situation, to implement all these mechanisms to reach a level of performance that is peer-acceptable. Further research work is undertaken to position those mechanisms in relation to all cited concepts within this paper and to include them in our model.

After modeling competency, it becomes possible for us to infer real knowledge and competencies throughout situated actions and interactions. However, the process of identification seems tedious and fastidious. Hence, we are working on systemizing this process in order to ensure the continuous inference of competencies, help managers easily and better decide on the human resources' affectation according to their performance, collaboration and competencies development challenges.

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