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A model for the capitalization and formalization of collective competences

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Abstract – In a constantly changing world marked by the omnipresence of technology, competences management has become a crucial element for the competitiveness and performance of companies. However, this management of competences has become a challenge due to the constant evolution of the company's activities, the complexity of the notion of competence and in particular that associated with cooperative activities. In this paper, we address this challenge by proposing a model of collective competence based on the activity. Unlike approaches based on the declaration of competences, we integrate their dynamic dimension due to their intrinsically iterative construction during the activity.

We begin by defining a terminological specification for the concept of collective competence, describing the various key characteristics. Next, we present our activity-based collective competence model, which represents the competences used by a collective during a given activity. We put our model to the test with the instantiation of competences through a real activity within a company. Our main contribution concerns the understanding and specification of collective competence as a complex notion, i.e. with emergent properties, to ensure better management of it.

Keywords – competence modelling, competence characteristics, collective competences, human resource management.

1 INTRODUCTION

Since the 1990s, the concept of competence has evolved considerably. The definitions proposed so far do not allow for a common perception of what a competence is. As noted by [Le Deist et Winterton, 2005], "it is impossible [...] to arrive at a definition capable of accommodating and reconciling all the different ways the term is used". This complexity is linked, firstly, to the multitude of concepts it deals with (knowledge, know-how, interpersonal skills, performance, etc.) and, secondly, a multidimensional aspect that encompasses the individual, the collective (work group) and the organization. While the topic of individual competences is the subject of an abundant scientific literature, collective competences are a surprisingly under-explored field. [Amherdt, 2000] explains that most of the time, the question of the generation and development of collective competences is either simply forgotten or deliberately avoided. [Beton et Bertolucci, 2020] point out that there is no evidence that putting together a team is enough to make it collectively competent. Moreover, there is a valorization of collective work, as a place of creation of a collective competence, without us really knowing what the

specificities and the mechanisms are. Indeed, in the scientific literature, it is often stated that collective competence is "more than the sum of individual competencies" [Amherdt, 2000 ; Le Boterf, 1995, 2016 ; Zarifian, 1999]. So, how can we detect these competences? And how can they be formalized and capitalized? In order to answer these questions, we first address the notion of collective competence and its characteristics, through an analysis of the scientific literature. In a second step, we propose a model for the formalization of this notion. Finally, we present an example of an instantiation of this model.

2 COLLECTIVE COMPETENCE

2.1 Definition

Although research on this dimension of competence remains relatively weak compared to the individual dimension, a number of researchers have taken an interest in it, such as [Amherdt, 2000 ; Boreham, 2004 ; Chabani et Bendaoud, 2011 ; Dubois, 1993 ; Dupuich, 2011 ; Le Boterf, 1995 ; Leplat, 1991 ; Michaux, 2003 ; Rabardel, 1995]. In this section, we will try to highlight, from the major works on this

dimension, the main theoretical contributions. The notion of collective competence is detected in the context of the development of work collectives. More precisely, according to many authors, collective competences emerge through collective actions [Chabani et Bendaoud, 2011 ; Dupuich, 2011 ; Le Boterf, 1995 ; Loufrani-Fedida, 2006 ; Michaux, 2003]. Table 1 lists the main contributions to the definition of the collective competence over the past twenty years.

Tableau 1. Contributions to the definition of collective competence

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| [Guilhon et Trépo, 2000] Set of knowledge (learned and formalized, tacit and explicit) involved in a production process, acting in an organization. Collective competence is composed of the products of the interaction of individuals from the same or different professions. It is the result of the encounter between the organization and the environment through the interpretation that creates and defines a language and a mode of coordination between people. |
| [Amherdt, 2000] All the know-how that emerges from a work team, combining the endogenous and exogenous resources of each of the members, and creating new competences from synergistic combinations of resources. |
| [Bataille, 1999] The ability of a work collective to deal with a situation that could not be handled by each of its members alone. |
| [Michaux, 2003] Tacit knowledge and know-how (shared and complementary) or informal exchanges supported by solidarities that participate in the "repeated and recognized capacity" of a collective to coordinate in order to produce a common result or co-construct solutions. |
| [Guerbette, 2009] A combination of differentiated knowledge placed in a situation in order to reach a common objective. |
| [Ruuska et Vartiainen, 2005] The ability of a group to work together toward a common goal that results in the creation of a collective outcome that could not have been accomplished by a single individual due to its complexity. |
| [Beton et Bertolucci, 2020] The ability of a work collective to deal with one or more situations that cannot be handled by a single individual, in order to achieve a common goal. |

Collective competences thus appear in autonomous or semi-autonomous operational team projects, or informally when groups emerge around a common professional objective. We find this approach in the majority of works, in particular those of [Amherdt, 2000 ; Dupuich, 2011 ; Loufrani-Fedida, 2006]. According to [Le Boterf, 2016], individual competence only becomes interesting if it can deal with the competence of others. The notion of interdependence then appears as one of the starting points for the emergence of collective competences. According to [Beton et Bertolucci, 2020] collective competence would be the recognized capacity of a working group to face a situation that could not be assumed by each of its members alone. It's worth noting that a work collective is defined as a situation in which there is interdependence between team members.

2.2 Common characteristics of collective competence

[Loufrani-Fedida, 2006] has identified five recurring conditions of existence of collective competences: the search for collective intelligence, the development of shared representations, effective interpersonal communication, efficient cooperation between team members and collective "knowledge to learn" from experience. From our point of view, it is not guaranteed that all these conditions are necessary to identify a collective competence. In the absence of proof, we will rather refer to common characteristics without prejudging the strict presence of the five. To these conditions or characteristics we add a shared leadership that represents a facilitating element of teamwork [Brulhart *et al.*, 2019].

The search for collective intelligence: According to [Amherdt, 2000], the search for collective intelligence is a determining factor in the emergence and development of collective competences. It can be defined as the result of an optimal mobilization of individual competences to create synergies that contribute to the pursuit of a common goal [Amherdt, 2000]. Collective intelligence can only be attested to when "we observe the collective use, within a company, of scattered information held by different individuals at work and that this approach aims to create a consensus for collective action through individual and collective cognitive processes" [Amherdt, 2000, p. 29]. As a result, companies can no longer be satisfied with the individual actions of their actors, but must integrate them into harmonious and creative cooperative relationships.

The development of shared representations: Applied to the study of collective competences, the shared representation is considered as a dynamic construction. Developed in social interaction, carried out by actors, collective representations are shared on the basis of shared values (mutual respect, professional ethics, etc.) on which individuals can participate, motivate themselves and find meaning in their own actions [Allard-Poesi, 1997 ; Loufrani-Fedida, 2006]. According to [Allard-Poesi, 1997], collective representations must be conceived not as shared representations, but as representations that allow individuals to structure their vision of reality in a similar way.

Effective interpersonal communication: According to [Le Boterf, 1995], individual knowledge and know-how only reach a state of collective competence when they are communicated and exchanged. The collective competence thus supposes, to exist, a situation of communication from person to person. In work groups, the common language, more precisely called working or professional language, plays an important role in the emergence of collective competence [Grimand, 1996]. If the technical terms are confusing for non-experts, the working language is oriented by the search for economy and efficiency. Indeed, professional languages are largely constructed from professional codes known and recognized by peers [Kogut et Zander, 1992].

Efficient cooperation between team members: Cooperation between team members is another characteristic of a collective competence. According to [Charles-Pauvers et Schieb-Bienfait, 2010], cooperation is even the key to collective competence. Facilitating and maintaining relationships of solidarity, ensuring the cohesion and synergy of work groups, and solving problems together are important factors for the development of collective competences [Brulhart *et al.*, 2019]. Through processes of adaptation and coordination in working groups, synergy effects can be developed collectively. Indeed, collective competence implies a set of individual capacities for joint action or co-production. It is by seeking to synthesize knowledge and experience that a collective competence is built. Team cooperation involves daily mutual support where members contribute their individual competences, discuss to solve problems and achieve a common goal.

A collective "knowledge to learn" from experience: Collective competences only exist when team members learn from their own experiences and learnings and apply them within the team, regardless of whether management mistakes, procedural errors, client misunderstandings, or method changes are positive or negative. All of these situations can be beneficial. It is a collective learning through shared

experiences and actions. Collective competences are formed by action through constant learning [Huber, 1991].

A shared leadership: Shared leadership is similar to team ownership. Leadership is distributed among the members and is not focused on one designated leader [Carson *et al.*, 2007]. It is presented as a management method that can improve team performance when performing complex tasks that require creativity and interactivity [Day *et al.*, 2004]. Shared leadership facilitates the following: (1) Information sharing [Carson *et al.*, 2007]. (2) A large pool of human and organizational resources [Daspit *et al.*, 2014]. (3) Interaction and participation between group members [Mehra *et al.*, 2006]. This contribution and freedom of expression within the group produces, on the one hand, not only innovative behavior, but also new collective knowledge and competences [Hoch et Kozlowski, 2014]. On the other hand, they strengthen the group's ability to solve the problems it faces [Dionne *et al.*, 2010]. In addition, shared leadership provides opportunities to enhance the socialization and social integration process of members [Carson *et al.*, 2007 ; Mathieu *et al.*, 2015] and thus builds collective trust (Nicolaidis et al. 2014).

The collective dimension of competence is complex to understand and explain according to the scientific literature review. It is difficult to understand how it emerges or develops. It is based on the synergy and dynamics of the group which are influenced by the relationships between members, their motivations, personal goals and other conscious and unconscious factors. This allows the creation of unique collective competences related to the group's objective. The collective competences are made up of: (1) know how to build a common understanding of the operational problems and the objective to be achieved; (2) establish a common operating language that represents the ability to communicate within the group; et (3) know how to cooperate in a group with different norms, cultures, resources, and cognitive procedures. We consider that collective competence is a concept that designates the capacity of a group or organization of people to work efficiently on a common task.

The general requirements of the collective competences are: (1) a collective intelligence, (2) shared representations, (3) an effective interpersonal communication, (4) an efficient cooperation between team members, (5) a collective "knowledge to learn", (6) a shared leadership.

For the formalization of this notion of collective competence, it is necessary to have a model that allows to represent these interactions between individuals and the dynamics of adaptation and resolution of complex situations. In the following section, we propose a dynamic formalization model for the representation of collective competences identified during an activity.

3 FORMALIZATION USING MODELS

Competence cannot be represented by a simple box because of its composite nature. Indeed, this concept is intangible and in a way subjective, since it is linked to an appreciation and a social judgment built following an observable result of a finalized activity. In this case, it is important to consider all of the elements that made it possible to qualify the competence.

A first model of collective competence is elaborated in this paper (Figure 1) allowing to consider the activity and its dynamics in the construction of these competences. Competence in this model is linked to the client's appreciation of an observed performance on a finalised activity. The model

is based on 7 basic concepts: activity, goal, situation, pattern, performance, customer satisfaction and individual competence.

Activity: organized combination of tasks (according to a logical process) and directed towards a specific goal. Competence is built in action, which implies the definition of a context [Miranda *et al.*, 2017]

Objective: designates the purpose of the activity (or activities). It must be specific, measurable, achievable, reachable, and time-bound (SMART).

Situation: a work situation is defined as a set of various entities and various interactions (of different types) that globally describe the external environment in which an actor exploits his competences [Belkadi *et al.*, 2009]

Scheme: organization of the activity (sequence of actions to perform an activity) composed of four elements [Coulet, 2011].

1. **Operational invariants:** Represent what the actor considers to be true, and what he considers to be relevant (e.g., the sky is blue / the cathedral is symmetric).
2. **Inference:** Covers the collection of information, calculations, and controls allowing the adjustment of the scheme to variations in the situation.
3. **Action rules:** Effective components that generate a sequence of actions leading to the desired result.
4. **Expected results:** The objective of the mobilization of the device.

Performance: A measurable result relative to the objectives we set for ourselves, the results we obtain, and the actions implemented to produce these results, using given means. Performance is associated with effectiveness and efficiency in a given context [ISO/FDIS 9000, 2015 ; Rhita, 2020]

Client satisfaction: the assessment of an expected result in relation to the client's expectations and needs.

Individual competence: a process of combining and mobilizing complex elements (personal resources and environmental resources) to achieve an activity within a SMART goal [Bemmami *et al.*, 2021].

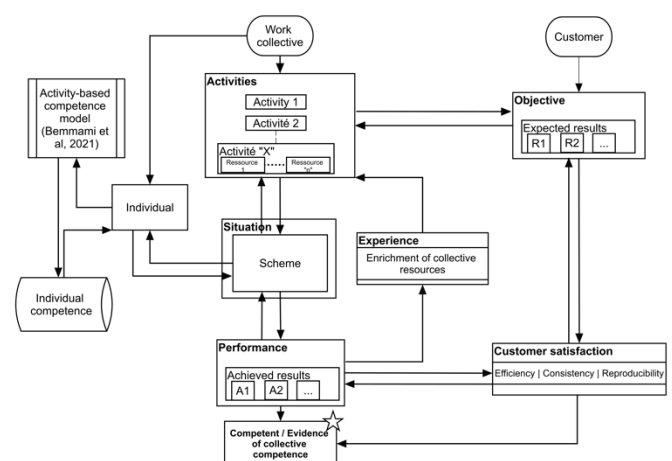


Figure 1. Dynamic model of collective competence

The activities are defined in accordance with the objective expressed by the client. In view of the evolution of the work situation, the activities can be redefined if necessary, by negotiating with the client an adaptation of the objective following the specificities of the new situation. Otherwise, the working group will have to make changes or corrections to the

current scheme. Figure 2 represents the process of adaptation and regulation of the activity pattern to take into consideration the evolution of the work situation.

All the actions necessary for the accomplishment of the activity and their attributions to the members of the collective are defined in the scheme. Each individual will have to exploit one or more competences to accomplish their actions as defined by [Bemmami *et al.*, 2021] in their activity-based competence model. After the activity is completed, a performance is calculated based on criteria defined by the client. Based on this performance, the client certifies or not the competence of the collective on the activity in question.

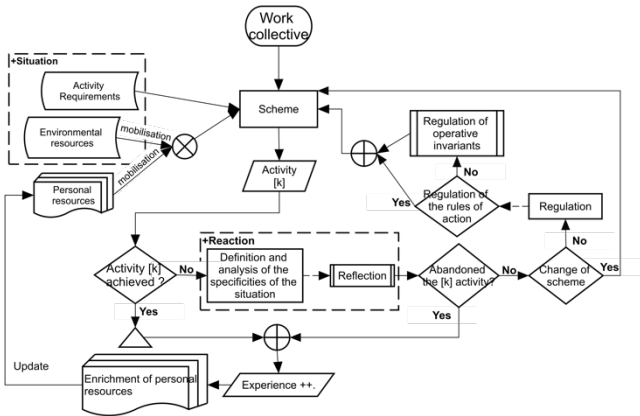


Figure 2. Process of carrying out the activity

In summary, the competence associated with a work group is identified through the activity performed, the performance observed and judged, and the work situation. The formalization by process diagram for this model allows to represent the dynamic construction of the competence through a process of perception and interpretation of the current situation.

For a better understanding and use of the model proposed in Figure 1, Figure 3 highlights the constituent elements of an identified competence.

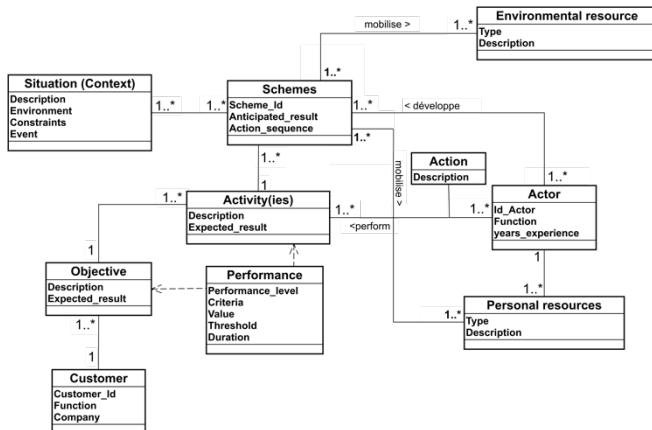


Figure 3. Structural model of a competence

The competence mobilized by the work group is identified in relation to the activity carried out, the various actors who participated in this activity through the actions carried out, the mobilized resources, the activity pattern, and the performance of the group.

In the following section, we will instantiate our model through an example in order to demonstrate the completeness of the

model and its ability to take into account the dynamics of the activity when the situation changes.

4 EXAMPLE

Our example of model instantiation (Figures 2 and 3) is based on a real activity within the company "Manaslu Ing", one of the partners of the ANR (French National Research Agency) project CaTCaP (Capture of the operational Traces of the company's actors to build human Capital and define the winning Processes) in which our work is included. The field of activity of this company is engineering and consulting with a strong technical expertise in the field of energy efficiency of buildings.

Figure 4 illustrates the dynamics of the "Building Modeling" activity as an example of instantiation. The activity is carried out by a group according to a specific scheme. The scheme is guided by the requirements of the activity (e.g. activity procedures, specifications, technical standards) in terms of environmental and personal resources to be mobilized. For example, in carrying out the activity, the collective performs a sequence of actions, such as reproducing the two-dimensional plan, moving to the 3D design and defining the materials.

Through these actions, each actor of the collective mobilizes, on the one hand, knowledge (e.g. reading an architect's plan, knowing the specifications of materials) and skills (e.g. designing from a technical plan). In addition, it requires software resources (e.g., Design-Builder™, Adobe Reader™) and work time.

At the end of the scheme, we check if the activity is performed, or if it is performed 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), in order to identify the potential causes. This analysis may indicate, for example, that some dimensions are not included in the initial plan, or that the volumes have a great geometric complexity.

The results of this process lead to a sub-process of reflection that will 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 of the work situations. For example, during this activity, if some dimensions are missing in the initial document, the scheme will be regulated to add a "manual completion of missing dimensions" action in the action rules.

At the end of the activity, whether it is completed or not, we have an acquired experience allowing to enrich the personal resources of the actor (e.g., competences concerning the design of complex geometries, or knowledge related to the use of CAD software).

The experience acquired during the regulation process ensures the renewal of competence, its maintenance, and its evolution so that it is not eroded. The purpose of the exploitation of a competence is represented by the expected results, which were associated with the initial objective. This competence is signaled by a recognized performance that serves as both proof and recognition of it. The loop that brings together the processes of analysis, reflection and regulation of the system around the specificity of the situation represents the dynamics of adaptation to variations in the context. An activity context similar to a previous one allows to consolidate the acquired competences and to improve their maturity level. However, a

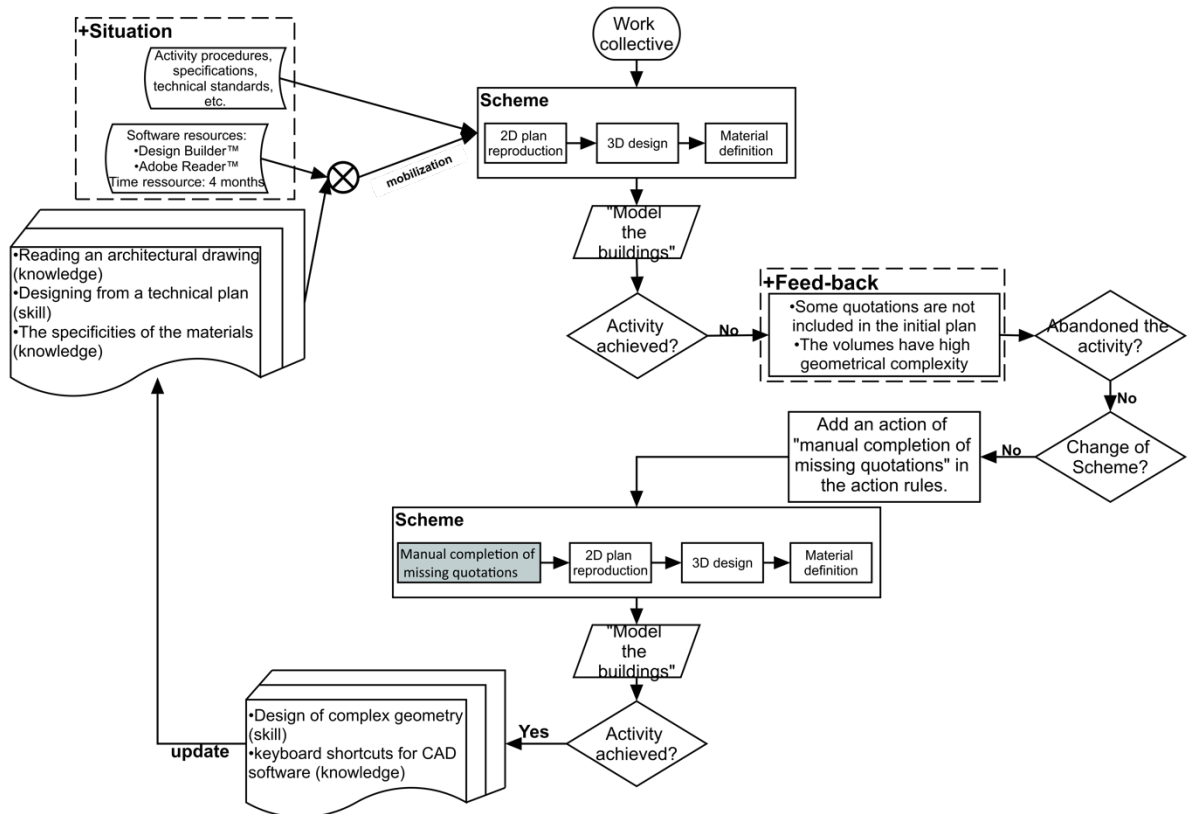


Figure 4. Example of the dynamics of the activity in light of the situation's evolution

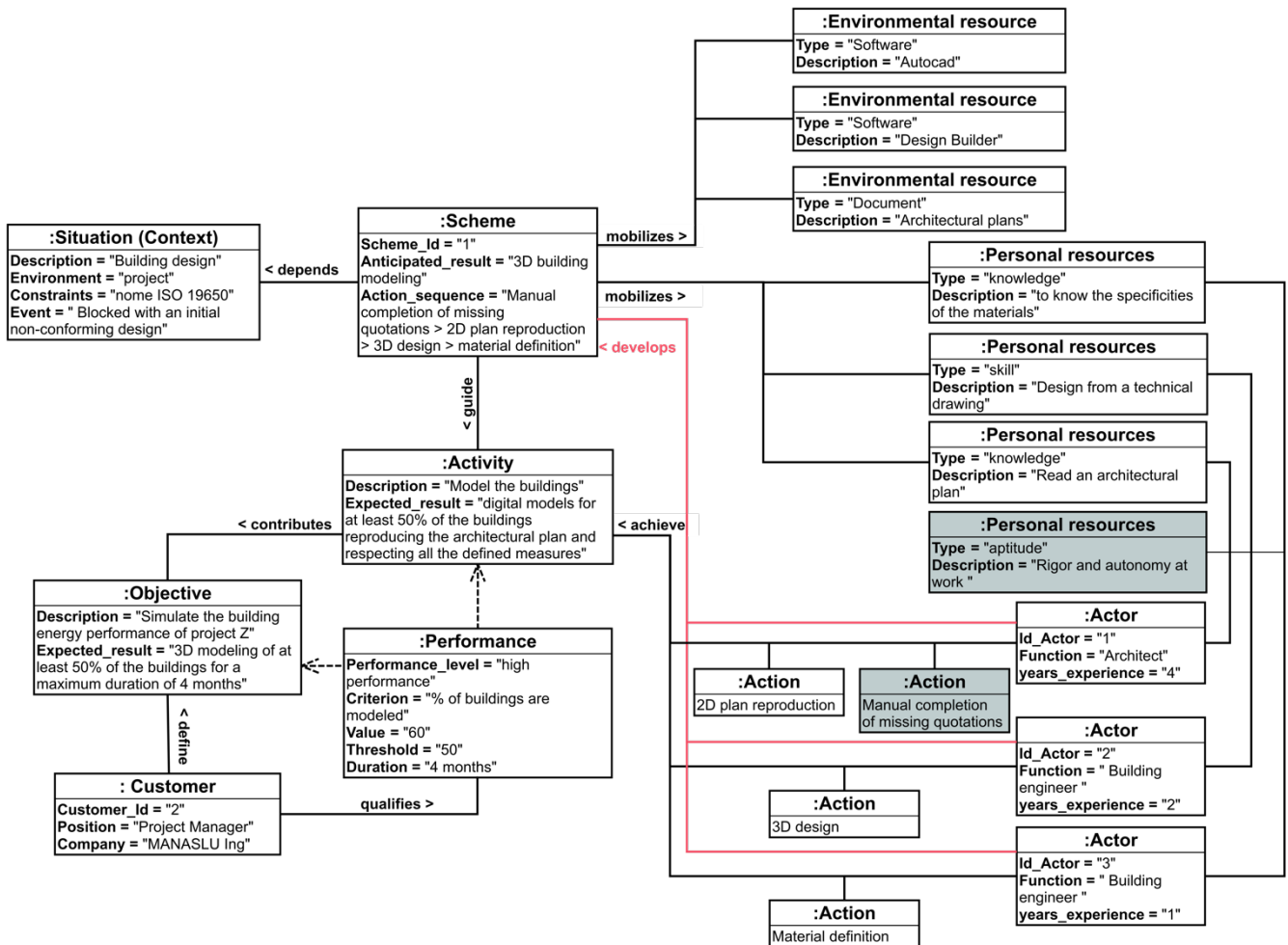


Figure 5. Instance of collective competence at instant

new context represents a richer learning opportunity and allows the development of new schemes and the acquisition of

new competences. The performance assessment is used as evidence of the identified competences.

Figure 5 represents an instance of the collective competence used at time "T" corresponding to a situation within a specific event (an initial non-conforming design). The competence used by the collective is identified in relation to the members of the collective carrying out the actions necessary for the completion of the activity, the activity itself, the performance observed and judged, and the situation.

The proposed model of competence is distinguished by its ability to represent the competences exploited in the context of a collective activity, while taking into account the evolution of these competences according to the situation. This example illustrates the adaptability and flexibility of our model in terms of covering the evolution of the work situation during an activity.

5 CONCLUSION AND PERSPECTIVES

In this paper, we have undertaken an in-depth analysis of the set of competences used during the various activities of a company, by defining the key characteristics of this notion. We have also highlighted the main elements that characterize the construction of a collective competence. Next, we proposed a model for formalizing this notion, which provides a clear and coherent structure for its understanding and evaluation. Finally, we presented a concrete example to try to validate our model, thus showing its relevance and feasibility. The perspectives for our work are numerous, including :

- Instrumentation of digital systems to automatically retrieve activity traces and build competences using our model for concrete use.
- The construction of a competence map including individual and collective aspects, in order to develop a more complete understanding of the set of competences used in the various activities of a company.

In the last year of the CaTCaP research project, we are developing a Web portal prototype (work in progress) including the kinematic chain going from raw activity traces to competences. The instrumentation using a trace-based system [Courtin, 2009] or a Web scrapping tool (such as Octoparse¹) of digital systems (such as Beesbusy² or Kanboard³) is at the beginning of the chain, while the mapping of the competences is more at the end, along with other competence monitoring tools that enable companies to make strategic decisions for instance. As there are many different tools in this kinematic chain, each specific tool is integrated in a slider of our Web portal with a very weak coupling so that it can be easily replaced by another one when necessary. In other words, there are input and output formats for each tool to switch from one tool to another through import and export operations. This Web portal is dedicated, among others, to researchers,

¹ <https://www.octoparse.com/> enables to extract automatically any Web data.

² <https://www.beesbusy.com/en/> is the project management system to plan tasks used by one of the partners of the CaTCaP project.

³ <https://kanboard.org/> is a free and open source Kanban project management software, which we have modified to be used to experiment with the coupling between tasks and some competence repositories, such as ROME in France and ESCO in Europe.

industrial managers and teachers who want to study a phenomenon, make strategic decisions or create a new competence-based training program, respectively.

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