From the Competencies to the Performance: An Approach

Meziane Bennour, Didier Crestani

FROM THE COMPETENCIES TO THE PERFORMANCE: AN APPROACH

M. Bennour, D. Crestani

LIRMM, 161 Rue Ada, 34392 Montpellier Cedex 5

Abstract: It becomes important to model and analyse the enterprise processes with regard to both human and material resources. This paper presents a method developed in the frame of an industrial project, to integrate individual and collective competence to estimate the performance of an activity of a process.

Keywords: Competence model, Performance evaluation.

1. INTRODUCTION

New production mechanisms like flexibility have anchored once more the human entity in the heart of the enterprise. Mostly overlooked before, human competencies must be included nowadays in the analysis of enterprise processes. This article presents first a review to show the characterization of human resources and its relation to the performance. Then the context of the study is explained and the proposed method using competencies to estimate the performance of activities is detailed. Its application to estimate the performance of enterprise process is briefly addressed. The conclusion points out its limitations, and several tracks that could improve it.

2. THE HUMAN A PERFORMANCE VECTOR

The industrial domain is not naturally focused on the human resource. However it cannot overlook it. Even though numerous studies have shown the importance of the management of the human resources for the control of the enterprise's performance (McEwan and Sackett 1998), few explicitly take it into account and prefer to focus on the material resources (Tchommo *et al.* 2003). In scheduling, the majority of the works includes the human resource only in terms of its availability and capacities (Gronalt and Harlt 2003). They identify it but only consider it as a material resource. However, to implement a politic of allocation, some researchers tried to model the impact of the human entity on the execution of an activity. For example (Boucher *et al.* 1995) consider that the manufacturing time depends on the effectiveness of the operators. The influence of the capacity of the training of the operators is explicitly taken into account to improve the productivity of an organization (Nembhard 2001) or its operating time (Mosheiov 2001). In other studies, more complex models have been developed to characterize the human entity and its competencies. Norman (Norman *et al.* 2002) considers that the process performance (productivity, cost) is the result of adding the performance from all the operators involved in its execution. He uses a multi level competence model where competencies are evaluated in a deterministic way. To describe the human entity, Pichot (Pichot 2001) adopts the competence model developed by Harzallah (Harzallah 2000). Franchini (Franchini 2000) uses the notion of Main Competence to characterize operators. The identification of the needs in competencies minimizes the costs of the allocation of the workers and adjusting best the workload. Askin (Askin *et al.* 2001) proposes the use of a model merged from soft sciences to describe the human resource. He integrates technical, organisational and psychological factors considered as valid indicators of work performance (Kolbe 1994). Lastly, researchers wanted to integrate a collective dimension to form autonomous production groups. To raise the productivity of a process, Jia (Jia 1998) distinguishes the business competencies. It identifies a set of transversal competencies through which the collective dimension emerges. El Mhamedi (El Mhamedi 1990) takes into account the collective work impact by defining criteria of cooperation to have a good constitution of groups.

Few studies explicitly acknowledge the relation between competence and performance. There is a lack of formalism. Some models at various granularities try to specify this relation. Some have just recognized the existence of workers into the enterprise. Others sought to model their influence, recognizing the importance of their training. The nature of the human entity has driven the researchers to develop the concept of competence. Moreover, the collective dimension of the work must complete this individual personality facet. This model complexity is limited to few studies. It can be pointed out the lack of interdisciplinary of the adopted methods, and in general their empiricism. The developed approaches ignore in general the collective aspect and the dynamics of the competencies.

3. CONTEXT OF THE WORK

This research was conducted with an industrial partner Merlin Gerin. Its goal was to define a method to estimate the performance of enterprise process.

3.1. Performance estimation principle

The basic idea, based on the observations of the industrial, is that it's possible to quantify the influence of competencies of the human resources on the process performances (quality, delays, etc.). The study of competencies relies on a set of interviews with the industrial expert. The developed method supposes that any activity is characterized, from each point of view, by a nominal performance. When carrying out activities, the influence of the human resources on the performance takes into account explicitly the impact of their competencies. These will then modulate (increase/reduce) the nominal performance of an activity, using laws which have been elaborated with the industrial expert.

3.2 The process example

The method of integration of the competencies will be illustrated for the computation of the performance of an enterprise process, termed as Production Authorization Process (PAP) (Fig. 1).

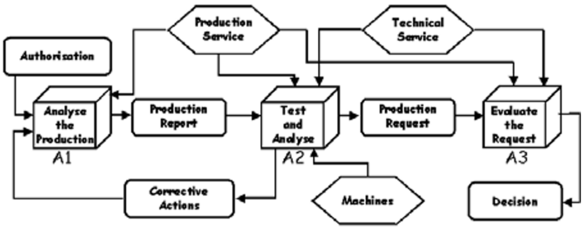

Fig. 1. Production Authorisation Process

The goal of this process is to authorize the production of a new industrial product. This process is decomposed into three activities A1, A2 and A3, and needs actors belonging to the technical and the production teams. The tests for the product are defined during A1. They are carried out in A2. Depending of the results of the tests, corrective actions are needed or a production order is generated. The production order is examined during activity A3 for a final decision. In the sequel the computation of the temporal peformance of activity A2 is studied. After the choice of the process, the model of competence used to estimate the performance is now explained.

4. THE COMPETENCE MODEL

The following synthesizes our position according to the competence concept and presents the entities used to describe the processes of an enterprise.

4.1 Activity, task, resource and competence

Like (Pourcel and Gourc 2002, Jia 1998) it can be considered that the concept of competence is tied both to the task and the human resource. The task is linked to its associated technical and human resources (actor). The activity is the realization of one or more tasks by one of several actors. Our vision of the competence is a multiform since it considers knownledge, know-how and behaviour. It is also a multilevel since it can be either individual or collective. The activity is characterized by a set of required competencies necessary to its execution. Human resources might have, at various degrees, a set of aquired competencies. These evolve with time in function of the professional activity (know-how), applied training plans (behavior) and individual capacities. In situation, when several employees must be considered, the collective dimension is taken into account using the relationship of the members of a team. The classification of competencies and their influence on the execution of an activity is now presented.

4.2 Estimation performance approach

The proposed method can be decomposed into two parts (Fig. 2). At first (E1) and independently of the affected staff, the nominal performance of the considered activity is decomposed according to the Business Domains (BD) implied and the competence necessary for its realization. In a second time (from E2 to E4), the individual and collective dimensions of the work are taken into account to estimate the impact of the competence on the performance of the activity.

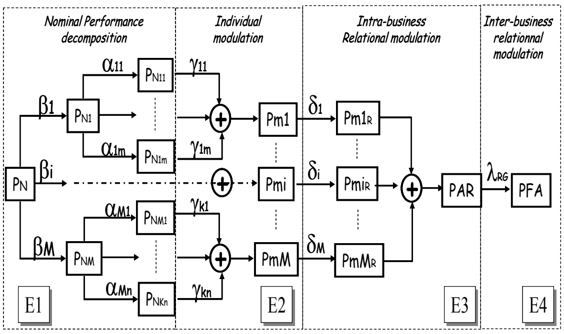

Fig. 2. Synoptic of the proposed approach

4.2.1 Required Main Competencies: Step E1

Each of the Business Domains (BD) necessary to carry out an activity necessitates a set of required competencies for its execution. Harzallah's work (Harzallah 2000) shows the variety in knowledge to take into account for a fine charaterization of a competence. Like Franchini (Franchini 2000), to limit the number of competencies to take into account, individuals are characterized by their Main Competencies. The latter are grouped into two classes. First a set of Individual Main Competencies MC_I (Technicality, Decision, Autonomy and Innovation) relative to the human entity considered independently of each other. Second the Collective Main Competencies MC_C (Relationnal and Management) that characterize the organization of the human relations between the different individuals and the set of occupational positions involved to take care of the collective dimension of labor for a group of employees. Once the Business Domains and the Main Competencies have been selected for a given activity, weighted factors (β_i, α_{ij}) are allocated for their relative contribution on the performance as illustrated on the Fig. 2. Values of these weight factors are determined, as in several studies (Jia 1998, Franchini 2000), using a multi-criteria method. Main Competencies are described in a hierarchy by a tree like structure that permits the evaluation of the associated weight factors on the basis of information given by the experts and using the AHP method (Saaty 1980).

4.2.2 Acquired individual competencies: Step E2

In our approach, the competencies of the individuals are characterized by a set of knowledge, know-how, and behaviour influencing the Main Competencies. Their impact is modeled using empirical and good sense laws established with the industrial partner. These laws evaluate the modulation of the nominal performance for a given Main Competence and their characteristics depend on the context of the activities.

4.2.2.1 Individual dimension of competence

For example, the MC_I Technicality can be tied to the duration of an activity using the graph in Fig. 3 that was empirically established with the industrial partner. The modulation coefficient evolves with the experience of the individual. A novice will rise the duration (γ positive), an expert would reduce it (γ negative). For a given training, knowledge and know-how can be identified. The behaviour of individuals can modify locally the slope of the curve.

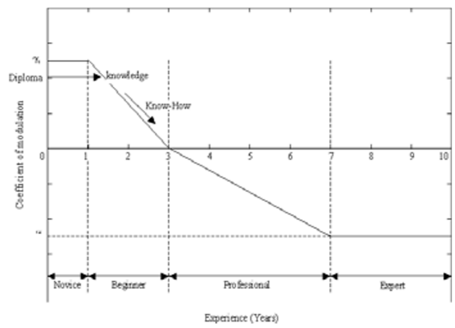

Fig. 3. Modulation coefficient and MC_I Technicality

In the same way, a histogram (Fig. 4) is used to evaluate in a context, an individual's capacity to decide (MC_I Decision). For example for a Technical task, an individual with administrative background isn't adapted. An engineer in a Technical context is more suited to decide (γ negative). In some cases, experience can override the previous rule, preferring a technician with experience to an engineer that has none.

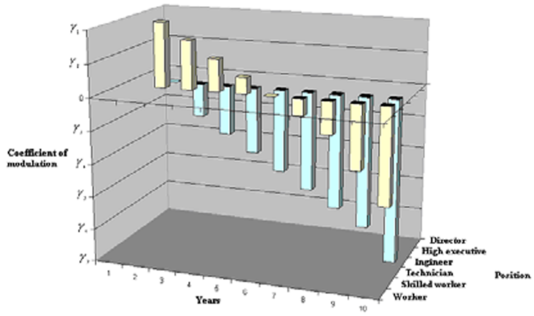

Fig. 4. Modulation coefficient and MC_I Decision

These curves allow to report the impact of a single individual on the activity A2, for the Production service. But they cannot be directly used for the Technical service which requires 3 persons. It is now necessary to integrate the dimension of the teamwork by being interested to the human relations aspect.

4.2.2.2. Collective dimension of competence

To take into account the collective dimension contextual laws are used. They translate the way according to which the individual competence of the partners of a same Business Domain can be aggregated. For example, for the MC_I Technicality of the Technical service of the activity A2, the modulation coefficient of the group $\overline{\gamma_{TT}}$, is obtained by averaging the individual coefficient (Equation 1).

$$\overline{\gamma}_{TT} = \sum_{i=1}^{i=3} \frac{\gamma_{TT}(i)}{3} \qquad (1)$$

Although being in the presence of a group, it can be considered that the decisional dimension of the work depends on the position and the seniority of the group leader of the technical department using the empirical graph in Fig. 5. Here, in context, it can be considered that in a group, it is the one with the most experience that assumes if necessary the responsability of taking decisions. Hence, in this case the use of an averaging law is rejected.

4.2.2.3. The Business Domains performances

First the portion of nominal performance P_{NIJ}, for every Business Domain involved into an activity, for MC_I (Equation 2) is determined.

$$P_{NIJ} = \beta_I . P_N . \alpha_{IJ} \ \ with \sum_J \alpha_{IJ} = 1 \qquad (2)$$

Secondly, on one hand, for each Main Competence, the coefficient of modulation leads by the employees is estimated. On the other hand to find the performance P_{mI} linked to Business Domains I of an activity (Fig. 3) it is enough to add the nominal performance P_{NIJ} associated to the J Main Competencies where their influence is translated by their modulation coefficients γ_{IJ} (Equation 3).

$$P_{mI} = \sum_J P_{NIJ} (1 + \gamma_{IJ}) \qquad (3)$$

However, it still remains to integrate into the estimation of the performance of the activity the human relations which often perturb strongly its execution. The importance of this relational dimension was often evoked in the framework of the constitution of working team (Bidanda *et al.* 2005) where the management of the conflicts is essential. The works of Murphy (Murphy 1994) identify the influence of the intellectual capacities, emotional and manager abilities for the resolution of the conflicts. The capacity of communication is also indispensable to the success of a teamwork. Bidanda (Bidanda *et al.* 2005) have underlined this point. They distinguish vertical and horizontal communications.

4.2.3. Intra-business Performance: Step E3

There is a very strong relation between behaviour and the relational capacities of individuals (relational MC_C). For the latter 6 levels (Fig. 5); are used to define an individual's behaviour in a group.

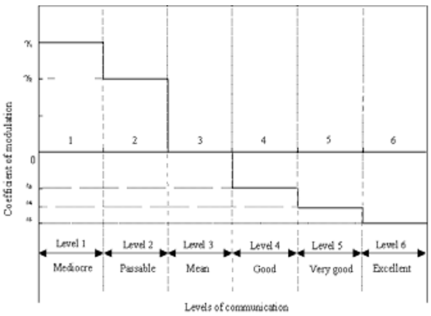

Fig. 5. Modulation coefficient and MC_C Relational

Every defined law characterizes only the individual. For a team work, contextual laws taking into account the influence of a set of employees on the performance are used. To translate the effect of group the intra-business relational level R_{GM} (Equation 4) is calculated. It determines the intra-business coefficient of modulation associated to the curve of the Fig. 6.

$$R_{GM} = E\left(\sum_{i=1}^{n} \frac{R_i(individual)}{n} \right) \qquad (4)$$

E: integer part function

n: number of individuals of a group

This formulation supposes that within the same business, individuals seek to limit their conflicts. The use of the averaging law stabilizes a team's relational level to an appropriate level. The function integer part measures the penalty that can be brought to the team (from its members). This work being realized for each of the Business Domains involved in the execution of an activity, allows to determine the performance P_{mIR} engendered by each of them. It integrates the relational intra-business dimension (Equation 5).

$$P_{mIR} = P_{mI}(1 + \delta_I) \qquad (5)$$

The performance of the activity P_{AR} integrating this dimension is the sum of all the P_{mIR} (Equation 6).

$$P_{AR} = \sum_I P_{mI}(1 + \delta_I) \qquad (6)$$

It still remains to integrate the horizontal relations.

4.2.4. Inter-business Performance: Step E4

In that case the same approach can be followed but the inter-business relational level R_M will then be obtained by Equation 7:

$$R_M = Min(R_{GM1}, \ldots, R_{GMi}, \ldots, R_{GMn}) \qquad (7)$$

R_{GMi} indicates the relational level of each of the Business Domain groups. This equation seeks to express the nature of the inter-business relations which are, most of the time, different from those in the intra-business. Using a minimisation law, supposes here that in case of conflicts between the teams, these (teams) will not try to minimize them. This will strongly increase the duration of activity A2. Using Fig. 6, the coefficient of modulation inter-business λ_{RG} can be determined. The final performance of the activity can be obtained. It includes the relational dimensions intra and inter-Business Domain by the Equation 8.

$$P_{FA} = P_{AR}(1+\lambda_{RG}) \quad (8)$$

5. FORMALIZATION OF THE APPROACH

The approach previously developed is now formalized and explicitly described with regard to the temporal aspects of the performance. For a given point of view the method supposes that the performance of an activity is characterized by its nominal value $P_N \neq 0$. The developed formulation of the *Final Performance* given by Equation 8 is equivalent to the Equation 9:

$$P_{FA} = (1+\lambda_{RG}).P_N.\sum_M \left[(1+\delta_m).\beta_m.\sum_k \alpha_{mk}.(1+\gamma_{mk}) \right] \quad (9)$$

λ_{RG}, δ_m, β_m, α_{mk}, γ_{mk} characterize the viewpoint k.
For the temporal point of view, an activity is characterized by its nominal performance $T_N \neq 0$. The expression of the Final Duration of the execution of an activity can be duplicated from Equation 8 by assuming that the weight and modulation factors have been determined previously for this point of view. The *Final duration* can be expressed by Equation 10:

$$T_{FA} = (1+\lambda_{TRG}).T_N.\sum_M \left[(1+\delta_{Tm}).\beta_{Tm}.\sum_k \alpha_{Tmk}.(1+\gamma_{Tmk}) \right] \quad (10)$$

λ_{TRG}, δ_{Tm}, β_{Tm}, α_{Tm}, γ_{Tm} characterize this viewpoint.

6. EXPERIMENTATION

The proposed approach has been used on a small enterprise that employs 24 persons working in various services with various levels of experiences and competence profiles. For example the Technical and Production services employ 3 teams of 3 persons.

6.1. Estimation of the performance of an activity

All the previously described elements allow to estimate the performance of an activity. Fig. 7 shows for a temporal aspect an example of the set of performances that obtained for the activity A2 of the PAP process. The nominal duration of activity A2 is 1170 mn. In Fig. 6 a large dispersion of the temporal performance in function of the chosen actors to carry out activity A2 can be observed. Even if the mean value of the duration (1562 mn) is in the neighboorhood of the nomimal value, it can vary from 900 to 2600 mn depending on the competence profiles.

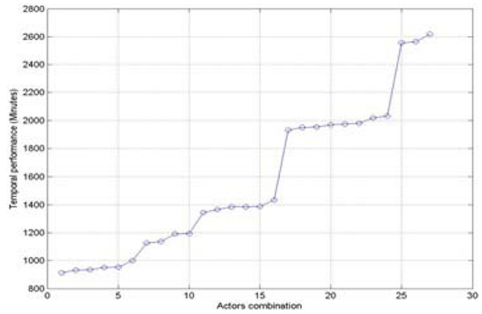

Fig. 6. Performance estimated for activity A2

The performance estimation method links the performance of an activity to the involved employees. Contrary to the industrial schedulers which consider the duration of an activity as constant (Grabot and Letouzey 2000), our approach leads to a performance dispersal around the nominal duration. This result can be confirmed by the conclusion of an inquiry which shows that near 70% of industrials consider that the skills of assigned operators inflence the activity duration (Grabot and Letouzey 2000).

6.2 Estimation of the performance of a process

The definition of composition laws for the local performances of the process activities, allows to compute the global performance of a process (Covès 2000). Fig. 7 shows the evolution of the duration of the PAP process for the sequence $\sigma=\{A_1,A_2,A_1,A_2,A_1,A_2,A_3\}$, and for a given choice of persons.

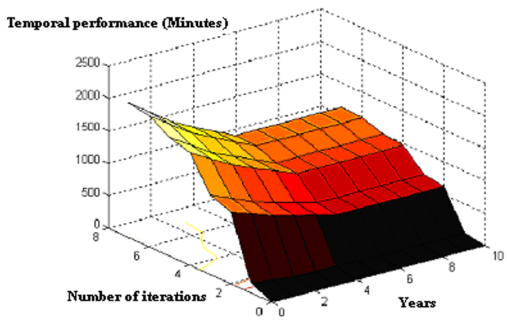

Fig. 7. Temporal Performance of PMP

The vertical axis corresponds to the estimated temporal performance of each activity. The depth axis is associated to σ (iteration index). The evolution of the competencies is visualized by the horizontal axis associated to the years. With the increase in experience, the duration of the process decreases and reaches a stable state when all the involved actors attain their maximal level of competencies.

7. CONCLUSION

This article proposes a method to integrate explicitly the concept of the competence in the computation of the performance of an activity. It distinguishes the individual from the collective aspect. However, this study has not the pretension to affirm that the human entity is reduced to a set of equations. But the relations between competence and performance exist. Some limits of the proposed method can be explained. On the one hand the model of the human resource can still be perfected. It should also seek to integrate in the individual competencies other social parameters such as motivation and in the collective dimension other cohesions factors than the purely relational aspect such as leadership. If the classification of these different concepts is seen always as attainable, their evaluation and formalization stay a more ambitious goal. On the other hand, the proposed method of performance estimation lacks as other methods. The definition of multiple weight factors is difficult to manage and have a tendency to muddy their impact on the performance. The relations between the various knowledge and the competencies even though evoked and assumed, are rarely formalized in all the reviewed studies. This work could draw on factorial analysis techniques but would necessitate an important investment. For example on the individual plan, the different personalities of the individuals can be evaluated. For the collective aspect, which would be more delicate to study, the personal behaviors in a group can be analyzed in detail. It is impossible to model the human entity in a totally deterministic manner. The study of the limits of fuzzy logic theory can be interesting. Anyway, the set of these ambitious perspectives could only rely on the development of parallel multidisciplinary studies associating researchers from both industrial and soft sciences. The firsts will seek to quantify competencies and performances; the seconds would define the limits of a formalization of the human entity and its behaviour in a work. This work can be used to develop more efficient and accurate methods for human allocation (Bennour *et al.* 2005).

8. REFERENCES

Askin, R. G. and Huang, Y., Forming effective worker teams for cellular manufacturing, *Int. Journal. of Production Research.*, 2001, **39** (11), 2431-2451.

Bidanda, B., Ariyawongrat, P., LaScola Needy, K., Norman, B. A. and Tharmmaphornphilas, W., Human related issues in manufacturing cell design, implementation, and operation: a review and survey, *Comp. & Indus. Eng.*, 2005, **48**, 507-523.

Bennour M. Crestani D., Crespo O., Prunet F., Computer aided decision for human task allocation with mono and multi performance evaluation, *Int. Journal. of Production Research*, 2005, **43** (21), 4559-4588.

Boucher, E., Legeard, B., Zidoum, H. and Guérineau, G., Utilisation de la PLC ensembliste pour la modélisation et la résolution d'un problème d'affectation, *GdR Automatique du CNRS*, Tours, 1995, 151-164.

El Mhamedi, A., Sur l'Intégration des Aspects Humains sur la Conduite Multi-Niveaux d'Ateliers de Production, PhD Thesis, INP de Grenoble, 1990.

Franchini, L., Aide à la Décision pour la Gestion des Opérateurs de Production : Modélisation, Planification et Evaluation, PhD Thesis, INP de Toulouse, 2000.

Grabot, B. and Letouzy, A., Short-term manpower management in manufacturing systems : new requirement and DSS prototyping, *Comp. in Indus.*, 2000, **43**, 11-29.

Gronalt, M. and Harlt, R. F., Workforce planning and allocation for mid-volume truck manufacturing : a case study, *I. J. P. R.*., 2003, **41** (3), 449-463.

Harzallah, M., Modélisation des Aspects Organisationnels pour la Réorganisation d'Entreprises Industrielles, PhD Thesis, Université de Metz, 2000.

Jia, T., Vers une meilleure Gestion des Ressources d'un Groupe Autonome de Fabrication, PhD Thesis, Université de Tour, 1998.

Kolbe, K., *Pure Instinct*, 1994, New-York : USA.

McEwan, A.M. and Sackett, P., The human factor in CIM systems: worker empowerment and control within a high-volume production environment. *Comp. in Indus*., 1998, **36** (1-2), 39-47.

Mosheiov, G., Scheduling problem with learning effect, *E.J.O.R.*, 2001, **13**, 687-693.

Murphy, J., Managing conflict at work, N-Y: Irwin, 1994.

Nembhard, D. A., Heuristic approach for assigning workers to tasks based on individual learning rates, *Int. Journal. of Production Research*, 2001, **39** (9), 1955-1968.

Norman, B. A., Tharmmaphornphilas, W., Needy K. L., Bidanda, B., Warner, R. C., Worker assignment in cellular manufacturing considering technical and human skills, *I.J.P.R*, 2002, **40** (6), 1479-1492.

Pichot, L., Baptiste, P., Ordonnancement des ressources humaines : étude de cas d'une entreprise d'injection plastique, *3ème MOSIM'01*, France, 2001, **2**, 707-714.

Pourcel, C. and Gourc, D., Présentation de la Méthode MECI, Ecole de Printemps du Groupe Modélisation d'entreprise, France, 2002.

Saaty, T. L., The Analytical Hierarchy Process, 1980 (McGraw Hill : New-York).

Tchommo, J., Baptiste, P. and Soumis, F., Etude bibliographique de l'ordonnancement simultané des moyens de production et des ressources humaines, *5ème Congrès International de Génie Industriel*, Québec, 2003.