

Modeling and performance evaluation of the skills production systems: Using the ECOGRAI method

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Abstract: - Nowadays, skills production systems are considered as manufacturing systems in terms of all the practices, rules, tools and methods that form the company's industrial culture. Our work aims to show that the methods and tools of systems engineering commonly used in industrial production systems are applicable in the field of skills production systems.

The present paper focuses on the study, the understanding and modeling the process of skills production system. Through this work, we seek to propose a mapping process for the skills production systems and present the results of applying the ECOGRAI method applied in the industrial production processes. The use of this method allows us to have an overall view of the system functioning while identifying the key functions, as well as the set of performance indicators related to each one of them.

Key-Words: - ECOGRAI, Mapping Process, Performance Indicators, Performance Evaluation, Production Processes, Skills Production Systems.

1 Introduction

It is often said that we live in an era of science, that our economy and our culture have become dependent on scientific research, and that even scientific methods foster our way of thinking [3]. Today, industrial organizations must respond to: the significant changing and exponential increase and evolution of technologies, the customer demand that requires a diversification in products and services and the competitive pressure that necessitates flexibility both in terms of product design and in the provided services. For industrial organizations to follow this evolution, several researchers and practitioners put in place performance measurement and evaluation tools. The role of these tools should not be underestimated, as they affect the strategic, tactical and operational control and planning.

Today, skills production systems (SPS) (training centers, educational system Institutions, Universities, Schools ...) are regarded as production systems for goods and services, in terms of the practices, rules, tools and methods that form the company's industrial culture [1].

Moreover, the SPS in the broadest sense in business administration is open to the outside world. Its socio-economic environment and its administrative tasks are its natural space during and after the deadlines of its production cycles; as well as all the inherent difficulties that go with it. But a SPS is not just that. It also has an internal life and special

problems that guide and influence its operation and determine its performance.

Contrary to industrial production systems where the quantitative aspect is predominant, in the skills production systems what prevails most is the qualitative aspect. This being said, evaluating the quality of a company's products remains controllable compared to the qualitative evaluation of the functioning of an SPS.

In the same vein, this service is neither easy to quantify nor is it easily assessable. Furthermore, it is difficult to assess the qualitative training performance of learners and trainers. In addition, conventional methods are becoming more and more difficult to apply in the design and piloting of such systems. Therefore, the SPSs are forced to go beyond the current management control practices in hindsight, and rather move towards an operational management control, based on the notion of piloting. Consequently, to evaluate the internal functioning of an SPS, a tool was imposed: The System performance indicator.

In this context and in order to ensure a better organization of management for a global control of a skills production systems, through this paper, we seek to introduce the notion of performance indicators in the definition of competence production system.

Our objective is to propose a mapping process for the system studied based on models of industrial

production systems. We also use the ECOGRAI as a performance assessment method applied in industrial production processes. The use of this method allows us to have an overall view of the system functioning while identifying the key functions, as well as the set of performance indicators related to each one of them.

2 Background

Before starting the study of the control systems for the skills production systems, it is paramount to present and to analyze the system that we are seeking to improve: the production system (PS).

Below, we will introduce it in an abbreviated form. Based on the fact that the majority of the views can be analyzed from a systemic view [4], it is common to break down the production system into three operating sub-systems Fig. 1:

- The physical sub-system representing the operating system;
- The information sub-system that enables the acquisition, the processing and the data management of the system and its environment;
- The decision sub-system which controls (identifies, analyzes and rectifies the derivatives by suggesting corrective or preventive measures) the physical system.

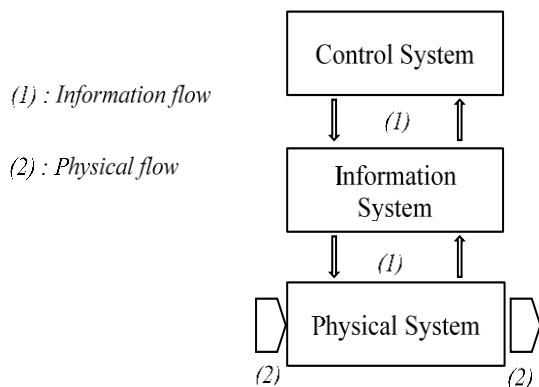


Fig. 1. The Production System [4]

This system breaking down might be relevant for companies by enabling its analysis, but it is less suitable for the industrial PS and its modeling. In the industrial PS, the information and decision sub-systems cannot exist if alone. Together, they make what we call the control system Fig. 2, the information and decision system or the director system [9][5]. Thus, it is truer to consider the PS as the association of a manufacturing system and a control system.

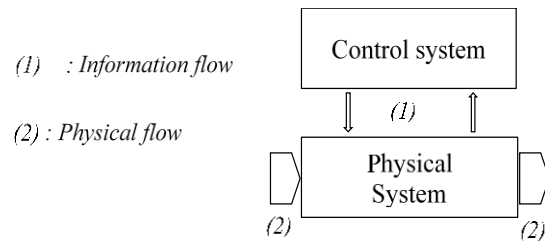


Fig. 2. The Industrial Production System

2.1 Concept of a control system and piloting structures.

The evolution of production systems has led to the emergence of the production systems control functions. Regarding this topic, many definitions can be found in various books on this subject. For instance, C. Berchet and D.Trentesaux have suggested an interesting synthesis of this notion in their research thesis [1]-[10].

According to J. Mélése [6] "flying a device implies choosing a goal, determining the best trajectory, launching the device and permanently correcting its deviations from its trajectory and, eventually, changing the trajectory, or even the goal itself, when the outside state of the universe, or that of the device show that the initial plan cannot be maintained".

Based on this definition, it can be inferred that Mélése qualifies the physical system by key variables (indicators) which are defined as indicators that enable the evaluation of specific objectives. The control system has action variables that define the rules of the functioning system. Three main control system functions could also be deduced Fig. 3:

- Measurement Function: Operation that consists in detecting the deviations between the key variables and the objectives set out;
- Monitoring Function: Operation that consists in determining the values of action variables according to the key variables values;
- Regulatory Function: Operation that consists in reducing the gaps between the targeted values and those implemented by modifying some of the key variables features.

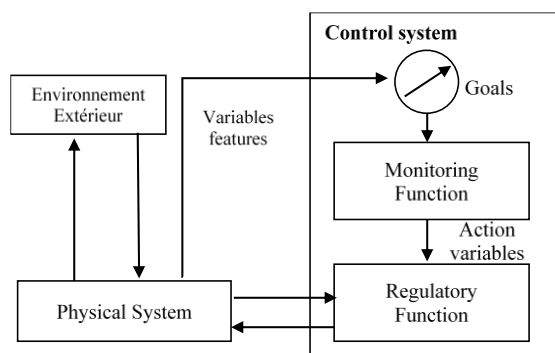


Fig. 3. The Control system model [6]

There are now several models to define the organization of piloting a production system. For our work, among the five piloting structures proposed by Thérouté [10], we favor the coordinated structure Fig. 4. because this structure, based on the hierarchical approach, allows communication between decision centers of the same level. The notion of communication, coupled with that of subordination on more than one level enables to increase the decision-making capacity of each level and to have a decision-maker that has an overall vision of its system's progress.

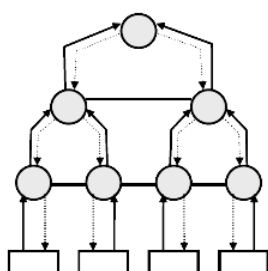


Fig. 4. Coordinated Piloting Structures

2.2 The concept of skills production systems

The definition of skills production systems, as adopted by Clementz [2] in his works, is based on the coherent way we can define SPS and any production system as it is usually defined in a company.

Indeed, in the case of the SPSs, competence constitutes the intangible product of the SPSs, since it constitutes the added value provided to the learner.

According to the works of Renaud on the observation of the situation of training systems, three types of actors have been identified [8]:

- The learner;
- Recruiting organization;
- The paying agency.

It is essential to identify these actors in order to be able to manage them and to meet their expectations. Fig. 5. presents the layout of actors in the SPS with:

- C_{n-1} = Learner's competence prior to system integration;
- C_n = Learner's Competence After system integration.

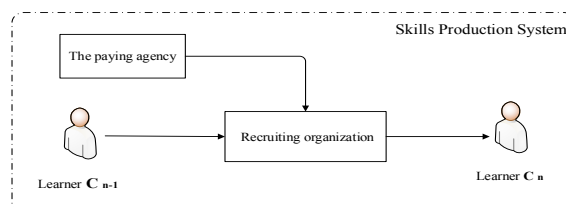


Fig. 5: Actors in skills production systems

2.3 Comparison between the Industrial Production Systems and the Skills Production Systems

According to Clementz's research studies, [2] on skills production systems, where he compared industrial production systems with skills production systems, the study highlights a number of similarities:

- Both systems have a complex organization of different and coordinated activities; The links between each of the activities do not provide information on the causes and effects of activities but rather on the logic of the flow path and, thus, determine the transformation processes;
- The activities of the two systems ensure the transformation of inputs into outputs by consuming allocated resources (human resources, technological resources, software resources);
- Both systems have activities controlled and ordered between them;
- Both systems complete cycles (loops of activities) to reprocess the output or information.

Clementz also found a certain functional analogy between a production system and a competence production system, particularly in its general organization structured into transformation processes composed of several activities. The Table.1 below illustrates the relationship that can be made between industrial production systems and the competence production system [7].

Table 1: summarizing the comparison between the industrial production systems / skills production system [2].

	Industrial production systems	Skills production systems
Production	Production of products	Productions of skills
Operational processes	Supply process Transformation process	Recruitment process Skills production process
Production program	Production plans	Training plans
Scheduling	Supply scheduling Production scheduling	Recruitment scheduling Skills production scheduling
Design of objects	Design office	Board of directors
Design process / methods	Methods Office	Teaching staff
Performance indicators:		
Costs	cost of products; Deadlines of manufacturing orders	Training / learner costs; Training program
Deadlines	Satisfaction of the need.	Constance of flows.
Quality		

2.4 Design of a performance indicator system.

Given the complexity of skills production systems, it is necessary to use a method to model several forms of this complexity. The effectiveness of a system or part of it is measured by one or more performance indicators against a standard plan established as part of an organizational strategy to meet strategic objectives.

Several methods establish a system of indicators to evaluate the performance of Industrial Production Systems. All these methods agree on the starting point which is to define the objectives of the studied system, what differentiates them is the way indicators are defined. Most methods do not explain how to determine indicators, except for the ECOGRAI method.

In order to be able to propose a performance evaluation method afterwards, we will first address the different notions and concepts of performance, namely the concepts of: performance indicator, performance indicator system. Then we will introduce the principles of the ECOGRAI method and its different stages.

2.4.1 Performance Indicators

A performance indicator is a quantified data that measures the effectiveness and / or efficiency of all or part of a (real or simulated) process or system, compared to a given norm, plan or a determined or accepted objective within the framework of a corporate strategy [17].

Berrah has distinguished different types of indicators: they can be classified according to the nature of the performance (external indicator, internal indicator), the improvement logic (progress indicator, control indicator), the level of piloting (strategic, tactical or operational indicators), the level of the piloting action (outcome indicator, process indicator), the number of action variables (simple indicator, complex indicator) or positioning of decision-making power (reporting indicator, piloting indicator) [18].

Generally speaking, a performance indicator is a measurement criterion associated with a specific action process. It must correspond to an objective and measure the attainment of this objective set by the external line of the organization unit.

2.4.2 Performance Indicator System

Due to the evolution of production systems, performance indicator systems (PIS) do now have more importance in the process of properly piloting production systems. They appeared in the early 1980s to take into account a multi-level expression and multi-criteria performance.

The role of PIS is to enable decision-makers to know the production system's status. They must use performance indicators as a control tool in order to measure the effectiveness of their actions and to respond to the overall objectives of the production system at appropriate response times [16].

In a general way [15]- [14], a PIS can be defined as a set of interacting indicators whose purpose is to measure the basic and general performance for piloting assistance.

3 Method

3.1 Description of the method ECOGRAI

ECOGRAI is a method to design and implement performance indicator systems (PIS) for industrial organizations. This method is applied with the involvement of the decision-makers of the production management system.

Thanks to its original approach, the importance of ECOGRAI lies not only at the level of the definition of performance indicators, but also at the level of the approach, that is the necessity of clearly defining the objectives, the variables of decision and the performance indicators in a hierarchical way. Furthermore, this method allows the obtainment of a limited number of coherent indicators, the action on the variables of decision modifying the value of these indicators. Conversely, other methods of defining performance indicators, first, do not identify decision variable, which does not necessarily imply coherence between objective, decision variable, and performance indicators. The ECOGRAI method and its triplet {objective / variable / measurement} has therefore been chosen to propose appropriate performance indicators in a logic of sustainable development Fig. 6.

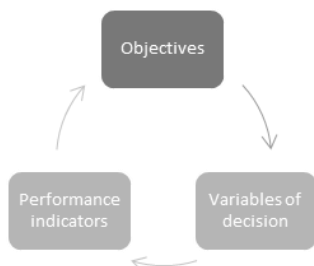


Fig. 6. Objective, Variable, Measure Triplet.

Implementation of a methodology as such thus involves the design, operation and revision of an indicator system. The life cycle of the defined indicator system depends on the life cycle of the system we are seeking to improve. The use of indicators is indeed important for a performance monitoring system as these indicators help to define the data to be collected in order to measure progress while comparing the actual results obtained over time with the expected results. Therefore, they are an indispensable management tool to make decisions in order to achieve the company's goals.

Several researchers have used the ECOGRAI method to determine performance indicators. To illustrate with an example, the authors Kallel and Al, applied this method to develop performance indicators of a maintenance process [19]. Frédéric

Bonvoisin used the ECOGRAI method to develop performance evaluation tools for hospital operating rooms [20]. In Mouss and Al, the authors used the method to develop performance indicators in order to improve the traditional approach of managing a production system for Aurès, a dairy product company [21]. In Robin and Al, the authors proposed a performance evaluation model to evaluate a product design system and to monitor its evolution [22]. In Bitton, the author used the ECOGRAI method to design a dashboard structure supporting a high degree of automation plant [23].

3.2 The application procedures of the ECOGRAI method

The ECOGRAI method proposes a design approach to the performance indicator system that is divided into six phases. These phases allow the process to be carried out while respecting the two main steps of the method: the design (phases 0 to 3) and the implementation of the indicator system (phases 4 and 5). Each phase has a precise objective, dedicated tools and a realization procedure Fig. 7.

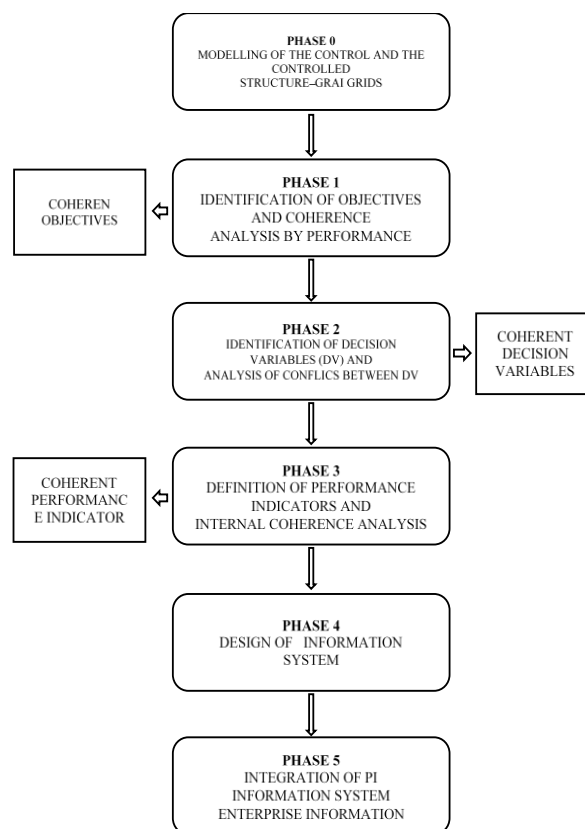


Fig. 7. Six phases of the method ECOGRAI.

The first phase aims to model the piloting structure of the production system and to determine the decision centers where the performance

indicators will be defined. The next phase aims to identify the objectives and then to analyze the consistency of the objectives after each phase of the identification to ensure a good coordination and a good synchronization of the decision-making process. The third phase is used to identify the decision variables that are the variables on which decision-makers act to push the system forward so that it can achieve its objectives.

The fourth phase consists of identifying performance indicators and analyzing internal consistency. The fifth phase is used to design the performance indicator information system. The final phase is used to integrate the performance indicator information system into the enterprise management system.

The first four steps were carried out during the drafting of this paper, which was not the case for the last two stages. Indeed, the last two stages will be dealt with in our subsequent work.

4 Case Study

4.1 Mapping Process of the Skills Production Systems

The skills production systems are composed of a complex structure and operation. However, the analogy is strong with the production systems [2] and, in this sense; the models presented in the preceding paragraphs inspire us. The Fig. 8. illustrates its mapping process.

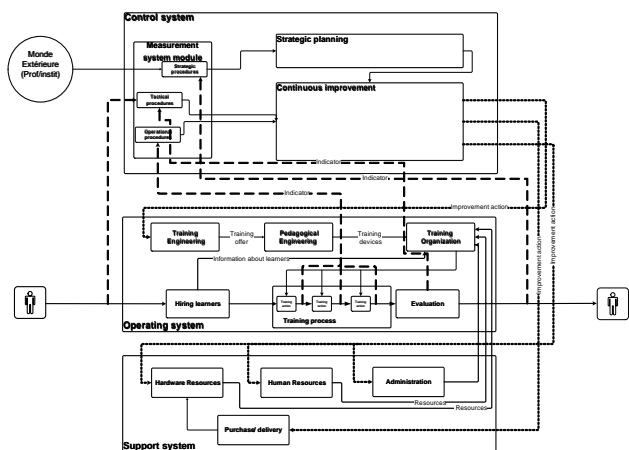


Fig. 8. Mapping Process of the Skills Production Systems.

4.2 ECOGRAI Implementation of the Skills Production Systems

The case study presented below concerns a training organization. We are going to resume phase by phase

unwound logic of the method ECOGRAI, and illustrate the end result for each of the phases. Only the first four stages were realized, the last two stages will be handled on our later works.

Phase 0: modelling of the structure and presentation of the GRAI grid.

In this first phase, we based ourselves on the GRAI grid as an approach of modeling of the studied system allowing to define the centers of decision. Every center of decision shows the performances of such a decision (objective and variable of action).

The Fig. 9. shows a functional grid established on the functions of the new plan based on the new mapping process of the Skills Production Systems:

- Columns: represent the functions;
- Lines: represent the decisions to achieve according to the various decision-making levels (strategic, tactical and operational). Every level is defined by period P and a horizon of time H. A horizon can be represented by one or several periods;
- A center of decision is the intersection between a function and a level of decision. Generally, a center of decision consists of an activity of decision, a relation of entrance and a relation of release;
- Arrows: the simple arrows represent the informative flow and the full arrows represent the decision-making flow between two centers of decision between a center of decision and the outside world.

H/P	Information Échange	Gère l'administration	Gère le Recrutement des Apprenants	Gère l'ingénierie développée de compétences	Gère l'organisation de la formation	Gère la production de la compétence	Gère l'évaluation	Gère le matériel	Gère les Ressources Humaines	Gère les actions	Information Interne
LEVEL : 10 H=5ans P=1 an	Evaluation des actions, des documents prof & besoins des entreprises	Moyen pédagogique	Definir le Nbre d'apprenants	Ingénierie de formation	Definir que effets de formation	Bilan qualité	Definir le matériel technique & pédagogique	Definir les RH	Recruter les Formateurs	Planifier les actions	Rechercher Formateurs, Sélection les actions
LEVEL : 20 H=6 Mois à 1 an P=1 mois	Validation des candidatures des apprenants	Definir le programme de recrutement des apprenants	Ingénierie pédagogique	Definir le programme de formation & accompagnement des modules pour l'action	Evaluation à la fin de l'action de formation	Maintenance & Programme d'utilisation des matériels Techniques	Recrutement des Formateurs professionnels	Achat des Matériels			
LEVEL : 30 H= 6 mois P= 1 semaine	Disponibilité des formateurs sur le mois	Gère les demandes	Definir le programme détaillé	Réalisation des actions de formation	Evaluation à court terme	Maintenance & adapter le matériel selon le programme	Ajuster les formateurs professionnels sur les Actions de formation				Disponibilité des salles

Fig. 9. Grid of the Skills Production Systems.

Phase 1: Identification of objectives and coherence analysis by performance aggregation.

Having identified, in the first phase, the centers of decision of the Skills Production Systems by the method GRAI, we shall subsequently identify the objectives of every center of decision by adopting a top-down approach, that is by identifying the main

objective of the system before coming down to the centers of decision of the GRAI grid.

Phase 1.1: definitions of the global objectives

These objectives were considered as the axiomatic basis of the study. We present in the Table 2. the system of global objectives:

Table 2. : Global objectives of training organization
Global objectives of training organization

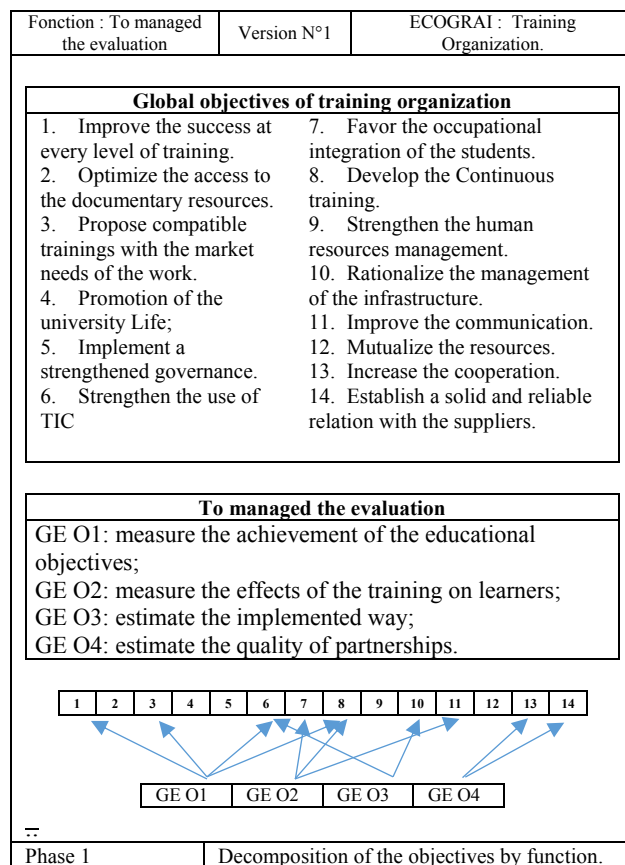
1. Improve the success at every level of training.
2. Optimize the access to the documentary resources.
3. Propose compatible trainings with the market needs of the work.
4. Promotion of the university Life;
5. Implement a strengthened governance.
6. Strengthen the use of TIC
7. Favor the occupational integration of the students.
8. Develop the Continuous training.
9. Strengthen the human resources management.
10. Rationalize the management of the infrastructure.
11. Improve the communication.
12. Mutualize the resources.
13. Increase the cooperation.
14. Establish a solid and reliable relation with the suppliers.

Phase 1.2: decomposition of the objectives by function.

As the global objectives have been defined, we have progressed to their decomposition function by function. The following example shows this decomposition in the case of the function to manage the evaluation. The Objectives of the function Managed the evaluation (GE On) as:

- GE O1: measure the achievement of the educational objectives;
- GE O2: measure the effects of the training on learners;
- GE O3: estimate the implemented way;
- GE O4: estimate the quality of partnerships.

A diagram of decomposition shows how every objective contributes to the realization of a greater objective.



Phase 1.3: decomposition of the objectives by center of decision.

We continue the decomposition of the objectives, but this time, at the level center of decision. The principle of decomposition remains the same, which is based on the notion of contribution to the superior level objectives.

We continue with the example of the function managed the evaluation Centers of decision "Evaluation at the end of the training action" Level 20 (GE E₂₀ O_n) that affects the following objectives:

- GE E20 O1: measure some satisfaction of the learners;
- GE E20 O2: estimate learnings;
- GE E20 O3: estimate the implemented educational ways.

Fonction : To managed the evaluation	Version N°1	ECOGRAI : training organization.
To managed the evaluation		
GE O1: measure the achievement of the educational objectives; GE O2: measure the effects of the training on learners; GE O3: estimate the implemented way; GE O4: estimate the quality of partnerships.		
« Evaluation at the end of the training action » Level 20		
GE E20 O1: measure some satisfaction of the learners; GE E20 O2: estimate learnings; GE E20 O3: estimate the implemented educational ways.		
Phase 1	Decomposition of the objectives by center of decision.	

Phase 2: Identification of decision variables (DV) and Analysis of conflicts between DVs

We recall that the variables of decision are the variables on which the decision-makers act to develop the system so that he can reach his goals.

In this phase, we shall identify the variables of decision of the Center of decision. “Evaluation at the end of the training action”, can be presented as:

- GE E20 DV 1: check of the degree of satisfaction of the learners with regard to the general conditions of the learnings.
- GE E20 DV 2: control of the acquisitions of the learners.
- GE E20 DV 3: check of the level of the implemented performance of the ways.

We identify in Table 3. the necessary variables of decision to realize all the objectives of training organization described in the phase 1.

Table 3. Decision variable according to the objective achieved

	GE E20 DV 1	GE E20 DV 2	GE E20 DV 3
GE E20 O1	+	+	+
GE E20 O2		+	
GE E20 O3			+

After the identification of the decision variable, in Table 4. we introduce their associated conflicts:

Table 4. Conflicts analysis between decision variables

	GE E20 VD 1	GE E20 VD 2	GE E20 VD 3
GE E20 VD 1		**	*
GE E20 VD 2	**		*
GE E20 VD 3	*	*	

(**) Strong links (*) low links () No links

Phase 3: Definition of performance indicators and internal coherence analysis.

This phase consists in identifying performance indicators to be used as well as the analysis of internal coherence to make was given the chosen objectives. These performance indicators’ multiple roles are well determined and are not chosen in a randomly. They are defined, chosen and implemented in an orderly and coherent way, with the aim of helping the decision-makers to pilot towards the achievement of the objectives. We can identify the performance indicators as:

- GE E20 PI 1: Rate of access to training;
- GE E20 PI 2: rate of progress;
- GE E20 PI 3: Success rate;
- GE E20 PI 4: Ratio of the resources regarding human potential;
- GE E20 PI 5: Ratio of the resources regarding premises and equipment dedicated to the training.

The triplet {objective / variable / indicator} is presented for every variable of decision and every objective using the coherence table in Table 5.

Table 5: Internal coherence analysis

Fonction : To managed the evaluation		Level 20	Internal coherence analysis			
objective	GE E20 O1	*	**	**	*	
	GE E20 O2	**	*	**		
	GE E20 O3				**	**
	Performance Indicators	GE E20 PI 1: Rate of access to training	GE E20 PI 2: rate of progress	GE E20 PI 3: Success rate	GE E20 PI 4: Ratio of the resources regarding human potential	GE E20 PI 5: Ratio of the resources regarding premises and equipment dedicated to the training
decision variable	GE E20 VD 1	*	**	**	*	
	GE E20 VD 2	**	*	**		
	GE E20 VD 3				**	**

For example, the objective “Estimate Learnings” is associated with the decision “Control of the acquisitions of the learners”. His effects, very

relevant (strong link **) for the achievement of the objective, are then measured by indicators “Rate of access to training” and “Success rate”.

In the same way, the objective “estimate the implemented educational ways” is associated with the decision “check of the level of the implemented performance of the ways”.

Its effects, very relevant (strong link **) for the achievement of the objective, are then measured by indicators “Ratio of the resources regarding human potential” and “Ratio of the resources regarding premises and equipment dedicated to the training”.

5 Conclusion

In this paper, we have proposed the Mapping process of the skills production systems and the ECOGRAI method is proposed in a case study. The contribution of this paper is to use a generic GRAI grid in this method to have an overall view of the system functioning while identifying the key functions, as well as the set of performance indicators related to each one of them.

The first four phases were carried out during the drafting of this paper, which was not been the case for the last two phases. Indeed, the last two phases will be dealt with in our subsequent paper.

Because this paper is certainly perfectible, we believe it would be useful to envisage the additional study to analyze the coherence between objectives, variables of decision and performance indicators.

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