Towards an approach based on Multi-Agent System and ECOGRAI methods to Modeling and evaluating skills production systems

Abderrahmane RHOUZALI, Benayad NSIRI, Mehdi ABID

***Abstract*—** In their current environment, Skills Production Systems (SPS), which are considered as goods and services production systems, are obliged to follow the evolution of the evaluation tools of the performance. This evaluation remains difficult being given the complexity of these systems. It is then necessary to have a structured approach and adequate methodological tools.

Our work has for objective, in a first place, we propose a mapping process for the skills production systems based on models of Industrial Production Systems. In the second place, we present a practical approach applied in the industrial production processes (ECOGRAI method) to conceive a Performance Indicator System. Thus, we put in place an architecture based on the multi-agent systems MAS which can support the integration of new indicators.

***Keywords*—** Performance Evaluation System, ECOGRAI, Multi-Agent Systems, Performance Indicators, Skills Production Systems.

I. Introduction

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.

In their current environment, 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 Skills Production Systems.

In terms of design and development, the chosen information systems architecture has to allow us to implement our processes without having to reimplement all the system [3]. Modularity of the Multi-Agent Systems (MAS) makes possible this need, because we can intervene quickly and effectively to modify locally a MAS, while maintaining him operationally.

Our work has for objective, in a first place, we propose a mapping process for the skills production systems based on models of Industrial Production Systems. We also use the

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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

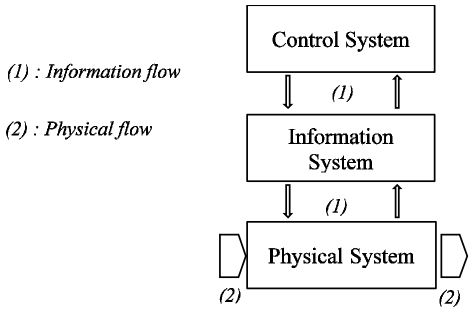


Fig. 1. The Production System [4]

identifying the key functions, as well as the set of performance indicators related to each one of them. Thus we put in place an architecture based on the multi-agent systems (MAS) which can support the integration of new indicators.

II. Background

Before starting the study of the control systems for the skills production systems, it is paramount to present and to analyze

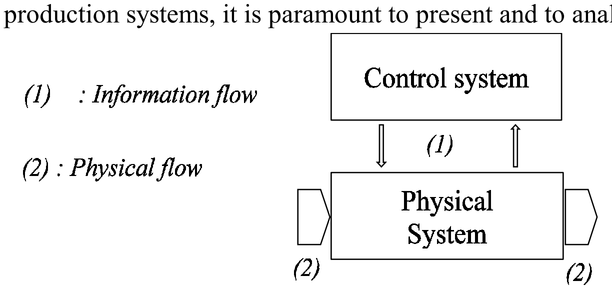


Fig. 2. The Industrial Production System

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.

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.

A. *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. Mélèse [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

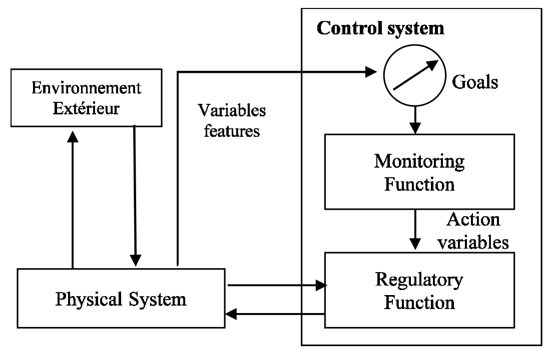


Fig. 3. The Control system model [6]

device show that the initial plan cannot be maintained". Based on this definition, it can be inferred that Mélèse 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

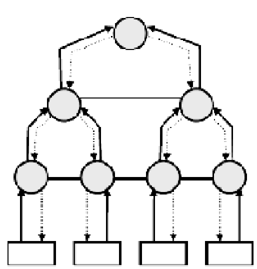


Fig. 4. Coordinated Piloting Structures

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.

There are now several models to define the organization of piloting a production system. For our work, among the five piloting structures proposed by Théroude [10], we favor the coordinated structure Fig. 4. because this structure, based on

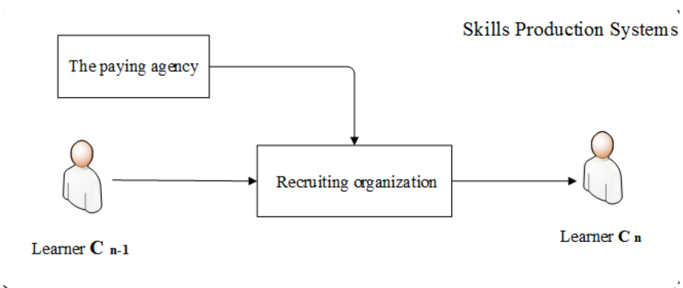


Fig. 5: Actors in skills production systems

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.

B. 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 Renauld 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:

- Cn-1 = Learner's competence prior to system integration;
- Cn = Learner's Competence After system integration.

C. 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 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;	Training / learner costs;
Deadlines	Deadlines of manufacturing orders	Training program
Quality	Satisfaction of the need.	Constance of flows.

D. 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.

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) *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.

E. *Agent and Multi Agent Systems (MAS)*

In literature, we find many definitions of the term agent. They have some similarities and vary depending on the type of application for which the agent is designed. Agents can be considered as autonomous construction software that can perform a predetermined task by different requests from an organization and at the same time react to its environment where other agents exist and interact with each other in case of a knowledge base shared [25].

According to several works [27] - [26] an agent can be characterized by:

- Autonomy: An agent can perform a specific task and control his actions to decide when he will act.
- Reactivity: Responds to changes.
- Proactivity: Demonstrates initiative to achieve its goals being able to respond to changes in the environment, including detection and communication to other agents,
- Learning: each agent is able to learn and modify his behavior according to his experiences within a system.

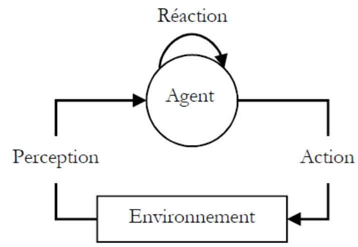


Fig. 6. Agent [24].

According to Wooldridge, MAS is a set of interacting agents to achieve their goals or accomplish their tasks [26]. Fig.7. presents the inside "social" aspect of the system, the interactions between the agents that make the behavior of the system [28].

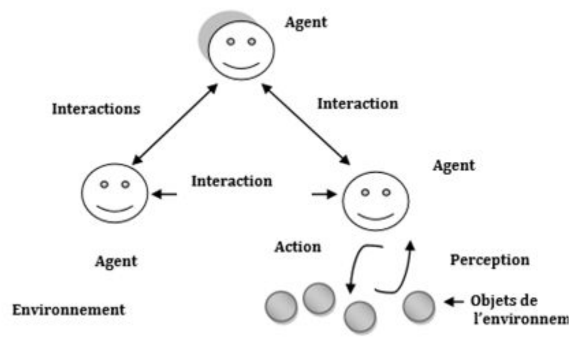


Fig. 7. Representation of an agent in interaction with its environment and other agents [28].

It can be direct through communications, as it can be indirect through action and perception of the environment. Interactions can be implemented in order to:

- Cooperate among agents, when they have common goals,
- Coordinate, to avoid conflicts and make the most of their interactions in order to achieve their goals,
- Create competition when agents have competing goals.

According to [30] - [29] an SMA is a system composed of agents that operate interact in an environment with an organized manner. Thus an SMA is defined according to the equation below.

SMA = Agent + Environnement + interaction + Organization(AEIO).

III. Method

A. *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. 8.

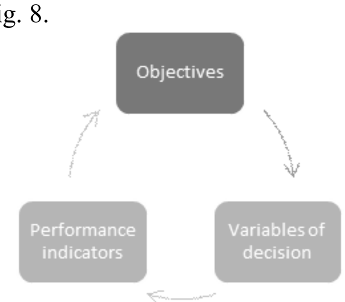


Fig. 8. Objective, Variable, Measure Triplet

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].

B. 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. 9.

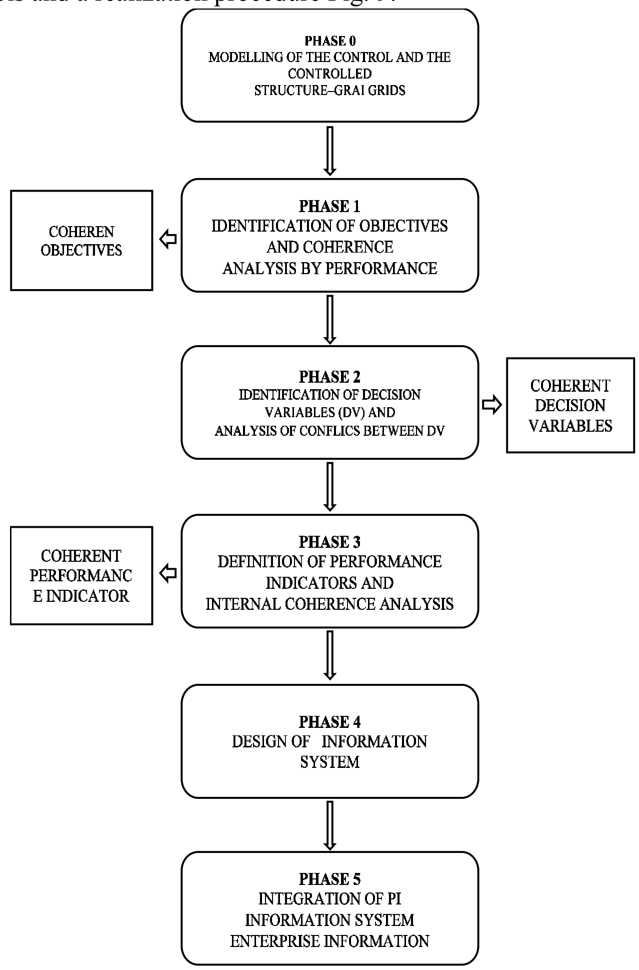


Fig. 9. Objective, Variable, Measure Triplet.

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.

C. The contribution of the multi-agent systems

Multi-Agent Systems (SMA) and the autonomous agents provided a new method to analyze, designer and implement sophisticated applications because they are a part) of IAD domain. [31]

Today, most applications require to distribute tasks between autonomous "entities" in order to achieve their goals in an optimal way. Because the classic approaches are generally monolithic and their concept of intelligence is centralized, the current applications are established with MAS

The orientation towards an architecture multi-agents was justified by several aspects. Indeed, in such a system, it is possible to add new agents or to modify the behavior of the agents without touching with the general structure. In a context of research, this upgrading capability is a considerable asset because it allows an iterative and incremental approach of development [8].

The approach multi-agents makes it possible to plan to have agents distributed in the environment while having the possibility of making them communicate between them. Consequently, the adoption of an architecture multi-agents appeared to us as the appropriate solution for the development of our system of analysis of the interactions.

IV. Case Study

A. 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. 10. illustrates its mapping process.

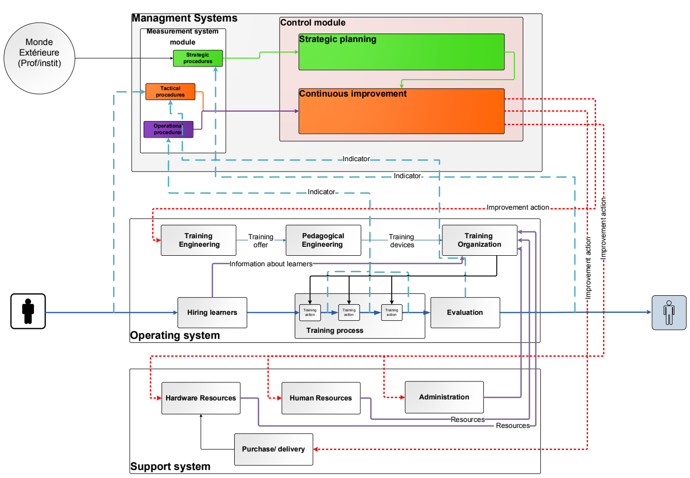


Fig. 10. Mapping Process of the Skills Production Systems.

B. 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.

1) Phase 0: modelling of the structure and presentation of the GRAI gird.

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. 11. 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.

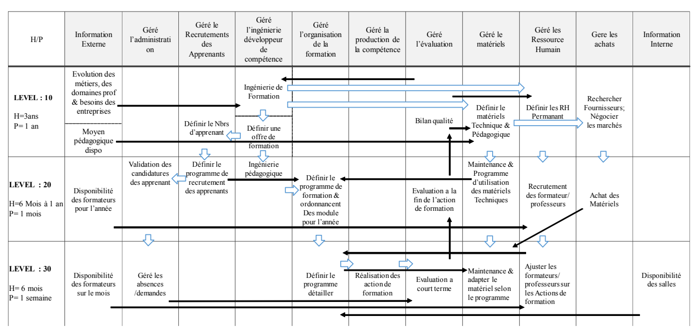


Fig. 11. Mapping Process of the Skills Production Systems.

2) 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.

a) Phase 1.1: definitions of the global objectives

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

Table II: Global objectives of training organization

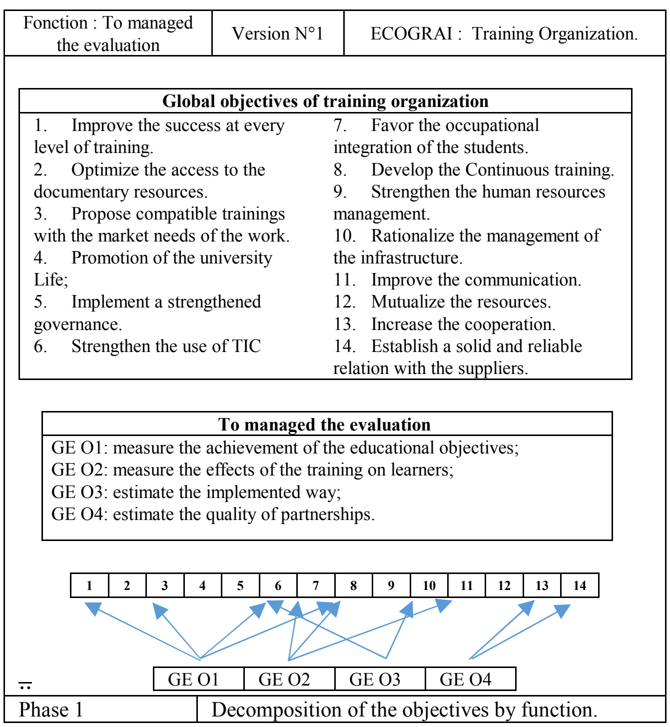
Global objectives of training organization	
1. Improve the success at every level of training. 2. Optimize the access to the documentary resources. 3. Propose compatible trainings with the market needs of the work. 4. Promotion of the university Life; 5. Implement a strengthened governance. 6. Strengthen 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.

b) 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 (G_E O_n) 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.

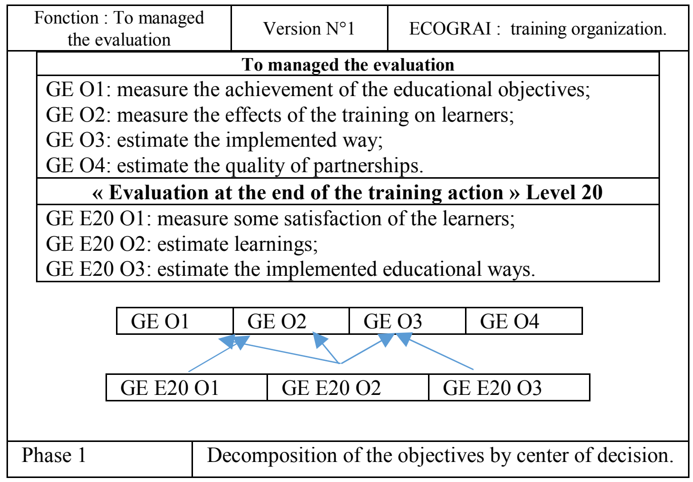


c) Phase 1.3: decomposition of the objectives by center of decision.

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 (G_E E_{20} 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.



3) 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 III. the necessary variables of decision to realize all the objectives of training organization described in the phase 1.

Table III. 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 IV. we introduce their associated conflicts:

Table IV. 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

4) 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 V.

Table V: 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".

C. Proposed Multi Agent Systems architecture for Skills Production System.

We have tried to establish an architecture based on multi-agent systems Fig. 12. which can support the integration of new indicators which are developed by ECOGRAI Method, in order to have an optimal Skills Production system and to guarantee a good functioning at the strategic, tactical and operational level, this architecture allows us to control SPCs using 4 types of agents (Recruitment Agent, Operational Agent, Tactical Agent and Strategic Agent).

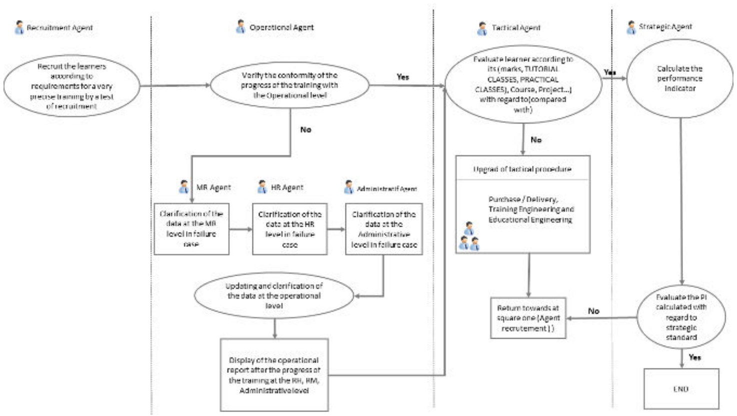


Fig. 12. Multi Agent Systems architecture for Skills Production System.

Once the recruiting agent carries out the task of recruiting learners according to the prerequisites posed by the committee of an organization, for a specific training action, via a recruitment and positioning program, after the completion of this task the latter reports to the operational agent by sending him the list of learners according to each training action.

This agent is also responsible for verifying the conformity of the training action at the operational level (the whole processes that gives the added value to the products of our system) and who is responsible for all the material resource processes, human and administrative, in case of malfunction, the latter (operational agent) ensures coordination, with 3 types of agents, to guarantee and establish a proper functioning of the training action:

- Material Resource Agent: Allows data clarification at the level of material resources (technical and educational materials) in case of failure.
- Human Resource Agent: Enables data clarification at the RH level in case of failure such as lack of personal and trainers.
- Administrative Agent: Let to clarify the different data within your assigned organization in the event of a failure, computer problem, or technical failure.

Once the problems are clarified by one or more agents (MR Agent, HR Agent, Administrative Agent), it will be possible to perform an automatic update of the data at the operational level.

The operational officer will display the operational report after the resolution of ambiguities in the HR, MR, Administrative level and recording them in the operational procedures to have a record and a history of each change or update of data at within this phase.

After the operations officer compares, processes, and resolves any ambiguous data within the operating system, in turn, the tactical agent, evaluates any entity in relation to each learner against the norms required by a pedagogical committee, in the case of a failure an upgrade will be performed by a structure of agents who will have all privileges to inspect and re-evaluate the processes of the support system and operating system (Purchase / Delivery, Training Engineering and Educational Engineering). In case that the ambiguity persists the transmission of information other agents will be mandatory and this by starting with the recruiting agent who must convey the information that is formatted and adapted to the language perceived and recognized by the multi-agent system.

Otherwise, if the system does not recognize any ambiguities (compliance with the norms in the tactical part) the strategic agent calculates the insertion rate and success of learners in the professional trades or with the resolution of engineering problems and this by evaluating the rate calculated against the strategic standards.

V. Conclusion

In this paper, we have presented 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 performance indicators and proposes an architecture an architecture based on multi-agent systems which can support the integration of new indicators which are developed by ECOGRAI Method, in order to have an optimal Skills Production system and to guarantee a good functioning.

VI. References

[1] Berchet C. (2000). Modélisation pour la simulation d'un système d'aide au pilotage industriel. Thèse en Productique, INSA de Lyon, France.

[2] Clementz C. (2000). Modélisation des systèmes de production de compétences: apports à l'ingénierie pédagogique. Thèse en Automatique et Productique, Université de METZ, France.

[3] Oumaira. I and Messoussi. R and Touahni. R, Instrumentation des activités des tuteurs à l'aide d'un système multi-agents d'analyse automatique des interactions, ARIMA:1947 - REVUE AFRICAINE DE LA RECHERCHE EN INFORMATIQUE ET MATHÉMATIQUES APPLIQUÉES, 11 août 2016, Volume 14 - 2011 - Numéro spécial CARI'10,

[4] Le Moigne. (1990). La théorie du système général: théorie de la modélisation, 2ème édition, Paris.

[5] Le Moigne. (1994). La théorie du système général - Théorie de la Modélisation, Collection Classiques du réseau intelligence de la complexité, PUF, France

[6] Mélèse J. (1991). L'analyse modulaire des systèmes AMS: une méthode efficace pour appliquer la théorie des systèmes au management, Les éditions d'organisation, Paris, France.

[7] Pourcel C, Clementz C. (2005). CIMQUSEF, Ingénierie des systèmes de production d'objets et ingénierie des systèmes de production de services: une même approche ? L'exemple des systèmes de production de connaissances et de compétences, Meknès, Maroc.

[8] Renauld R. (2008). Contribution au pilotage des organismes de formation Application aux établissements de l'enseignement supérieur. Thèse en Automatique, Université de METZ, France.

[9] Rodde G. (1991). Les systèmes de production – modélisation et performance, Éditions Hermès.

[10] Trentesaux D. (2002). Pilotage hétérarchique des systèmes de production. Thèse en Automatique et Informatique des Systèmes Industriels et Humains. Université de Valenciennes et du Hainaut-Cambresis (UVHC).

[11] Théroude F (2002). Formalisme et système pour la représentation et la mise en œuvre des processus de pilotage des relations entre donneurs d'ordres et fournisseurs. Thèse de doctorat. Institut National Polytechnique de Grenoble, France

[12] Ben Zaida, Y. (2008). Contribution à la Conduite du Changement pour l'Évolution du Système Entreprise, Thèse de doctorat de l'Université Montpellier II, Montpellier.

[13] K.K.B.Hon, "Performance and Evaluation of manufacturing systems", Department of Engineering University of Liverpool, Liverpool, UK. Volume 54, Issue 2, 2005, Pages 139-154

[14] V. Clivillé, L. Berrah, G. Mauris et A. Haurat, " Comment élaborer de manière cohérente des expressions de performance élémentaires et agrégées", 5ème Conf. Int. Francophone de MOdélisation et SIMulation (MOSIM'04), Nantes, 2004, pp. 711-718.

[15] L. Berrah, G. Mauris et F. Vernadat, "Information aggregation in industrial performance measurement: rationales, issues and definitions", International Journal of Production Research, 2004, vol. 42, no. 20, pp. 4271-4293.

[16] P.M GALLOIS: Ouvrage sur les indicateurs de performance. Club Production et Compétitivité, Groupe "indicateurs de Performance" Novembre 1994.

[17] Association Française de Gestion Industrielle, Evaluer pour évoluer, les indicateurs de performance au service du pilotage industriel, ouvrage collectif AFGI, 1992.

[18] Berrah L. "L'indicateur de performance, concepts et applications ", Cépaduès éditions, 2002.

[19] K. Lobna, B. Mounir and K. Hichem, "Using the ECOGRAI method for performance evaluation in

maintenance process," 2013 International Conference on Advanced Logistics and Transport, Sousse, 2013, pp. 382-387.

[20] Bonvoisin, F., (2011). Évaluation de la performance des blocs opératoires :du modèle aux indicateurs. Thèse d'État, Université de Valenciennes et du Haina ut Cambrésis, pp. 24-84.

[21] Mouss, A. Baci, A. Koull, HL. Mouss, (1999). Elaboration d’un systèmed’indicateurs de performance pour le pilotage d’un système de production, Symposium International : Qualité et maintenance au service de l’entreprise.

[22] Robin V., Sperandio S., Blanc S., Girard Ph., (2005). Interactions modelling between factors influencing performance of the design process. Proceedings ICED2005, Melbourne

[23] Bitton, M., (1990). ECOGRAI: Méthode de conception et d’implantation de systèmes de mesures de la performance pour organisations industrielles. Thèse d'État, Université de Bordeaux I.

[24] Siebert J (2011). Approche Multi-agents Pour La Multi-Modélisation et Le Couplage de Simulations. Application À L’étude Des Influences Entre Le Fonctionnement Des Réseaux Ambiants et Le Comportement de Leurs Utilisateurs. Université Henri Poincaré-Nancy I, 2011.

[25] Roberto A. Flores-Mendez, Towards a standardization of multi-agent system framework, Crossroads, v.5 n.4, p.18-24, June 1999 [doi>10.1145/331648.331659]

[26] Wooldridge, M.J. and Jennings, N.R. Pitfalls of Agent-Oriented Development. In: Proceedings of th Second International Conference on Autonomous Agents (Agents '98), K. P. Sycara and M. Wooldridge (Eds.), ACM Press, May 1998.

[27] J. Fox, M. Beveridge, D. Glasspool, Understanding intelligent agents: analysis and synthesis, AI Communications 16 (2003) 139–152

[28] Ferber, J. 1995. Les systèmes multi-agents. Vers une intelligence collective. InterEditions, Paris.

[29] F.-S. Hsieh and J.-B. Lin, “A self-adaptation scheme for workflow management in multi-agent systems,” J. Intell. Manuf., pp. 1–18, Aug. 20131

[30] M. Miranda, M. Salazar, F. Portela, M. Santos, A. Abelha, J. Neves, and J. Machado, “Multi-agent Systems for HL7 Interoperability Services,” Procedia Technol., vol. 5, pp. 725–733, 2012.

[31] Robert H. Guttman, Alexandros G. Moukas, and Pattie Maes : Agent-mediated Electronic Commerce: A Survey, Software Agents Group, MIT Media Laboratory, (1998).