International Journal of Computational Intelligence Systems
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tcis20

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Published online: 12 Mar 2012.

International Journal of Computational Intelligence Systems, Vol.3, No. 6 (December, 2010), 815-831

A Multi-Criteria Decision Model for Architecturing Competence in Human Performance Technology

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Received: 11-06-2010; Accepted: 20-10-2010

Abstract

In a continuously changing environment, like globalization, technological innovation, restructuring and outsourcing, organizations can no longer cope without continually developing their competencies and human resources. As a result academic research and company practices have actively started to develop decision making models in operation and practices to meet toughening competence demands that, moreover, need to be developed at an ever faster pace. In this research paper, we bring together several processes and components in order to provide a comprehensive overview in search for conceptual representations designed to support and develop organizational competence mapping at the individual and organizational level. According to recent research, as a decision making tool Analytic Network Process (ANP) methodology may mitigate the elusiveness of the architecturing competence concept by assisting to determine the importance of criteria and selecting the best alternative between competency models.

Keywords: Human Performance Technology, Architecture of Competence, MCDM, Analytic Network Process.

1. Introduction

Since the 1990s, architecturing competencies have become the code words for the human resources and strategic management practices of recruiting, selecting, placing, leading, and training employees and evaluating employee performance. To be used successfully in an organization or other professional network, competencies must be inclusive or integrated throughout all of the human resources practices.[1-6] Although receiving significant attention in management research and business[7], the architecture of competencies concept still remains difficult to apply, due to the vagueness of the theoretical construct, and due to the lack of pragmatic procedures to make it actionable. As pointed out by several researchers, the competence concept remains at an abstract level, leaving practitioners without clear guidance for the application stage.[8-12] According to recent research, Analytic Network Process (ANP) methodology may mitigate the elusiveness of the architecturing competence concept by assisting to determine the importance of criteria and selecting the best alternative of competencies models. In this paper, we thus review the Human Performance Technology (HPT) literature in search for conceptual representations designed to support and develop organizational competence mapping at the individual and organizational level with the primary objective to identify, maintain, and develop competences in agreement with the corporate strategy. By taking a synoptic overview of the HPT representation, we position components of inputs, processes, outputs in an integrative framework[13] to assist practitioners in selecting the right components and processes of competence management and to inform managers / employees about future improvement and development needs. The proposed methodology has been primarily devoted to aspects of competence architecture, including but not limited to

- understand and manage the firm's competence configuration in order to create sustainable advantage,
- evaluating, analyzing, or assessing a competence architecture for suitability or fitness of task purpose-objective,
- capturing and communicating a competence architecture using decision making models and tools which may play a catalyst role in identifying, managing, and communicating organizational competences,
- modeling of work systems based on their architectural competence descriptions,
- to assist competence management, with particular reference to the processes of competence.

Therefore the goal of this paper is, to be able to effectively modeling the competence of employees and to prescribe effective ways in which individual and organizational competence can be improved and to identify human and organizational factors that are critical to achieving the full promise of competence architecture.

2. Human Performance Technology – HPT

For an effective human resources management, the enterprise will let the process of performance evaluation develop itself. Such an enterprise has to build a system which answers the needs of the enterprise as well as those of the individual.[14] HPT stresses a rigorous analysis of the requirements of organization, process and human performance for new work system design and/or identifying the causes for performance gaps, and attempts to provide new work system designs and/or solutions to improve and sustain performance, and finally to evaluate the results against the requirements - the so called competencies.[15] A competency is the capability of applying or using knowledge, skills, abilities, behaviors, and personal characteristics to successfully perform critical work tasks, specific functions or operate in a given role or position. Personal characteristics may be mental / intellectual / cognitive, social / emotional / attitudinal, and physical / psychomotor attributes necessary to perform the job [16-18] and extend[19] this definition to include both internal and external constraints, environments, and relationships related to the job or occupation. Motivations and perceptions of the work and one's self or talent also are viewed as influential in competently and successfully performing in a position.[1,20-22] In summary, competencies are specific personal qualities that are "causally related to effective and/or superior performance"[20], are common across many settings and situations, and endure for some time.[23] Therefore HPT can become the leverage organizations need to increase improved performance and focus on results using a variety of means and methods. This article uses the traditional HPT process approach of International Society for Performance Improvement (ISPI) as its guideline model.[24]

Thomas F. Gilbert[25] believed it was most necessary to focus on variables in the work environment before addressing the individual. The same dichotomy between the environment and the individual can be seen in Teodorescu and Binder's model[13] shown in Fig. 1. Gilbert makes clear that we must look at the entire set of variables or influences that affect behavior, not merely at training or some other sub-set of the whole performance system. Teodorescu and Binder prescribe a way to build a competence model that can be used to measure and increase an organization's progress towards achieving competence. [13] Their model is shown in Fig. 1. Important inputs include the goals of the organization. Processes are built to identify and confirm the goals, conduct performance analyses, and so forth. Then remedial actions are planned and implemented as needed.

Individual and organizational competencies are intertwined. Studying only one or the other will not do. This idea reinforces our position that simply examining performance gaps and measuring their deficiencies will not do. We need to understand the root causes of those deficiencies. In fact, the competence of an organization is intertwined with the competence of individuals.

3. Architecture of Competence (AoC) in Respect to HPT

The competence architecture of an organization is the ability of that organization to grow, use, and sustain the skills and knowledge necessary to effectively carry out architecture centric competence practices at the individual, team, and organizational levels to produce performance goals with acceptable cost that lead to systems aligned with the organization's business goals.

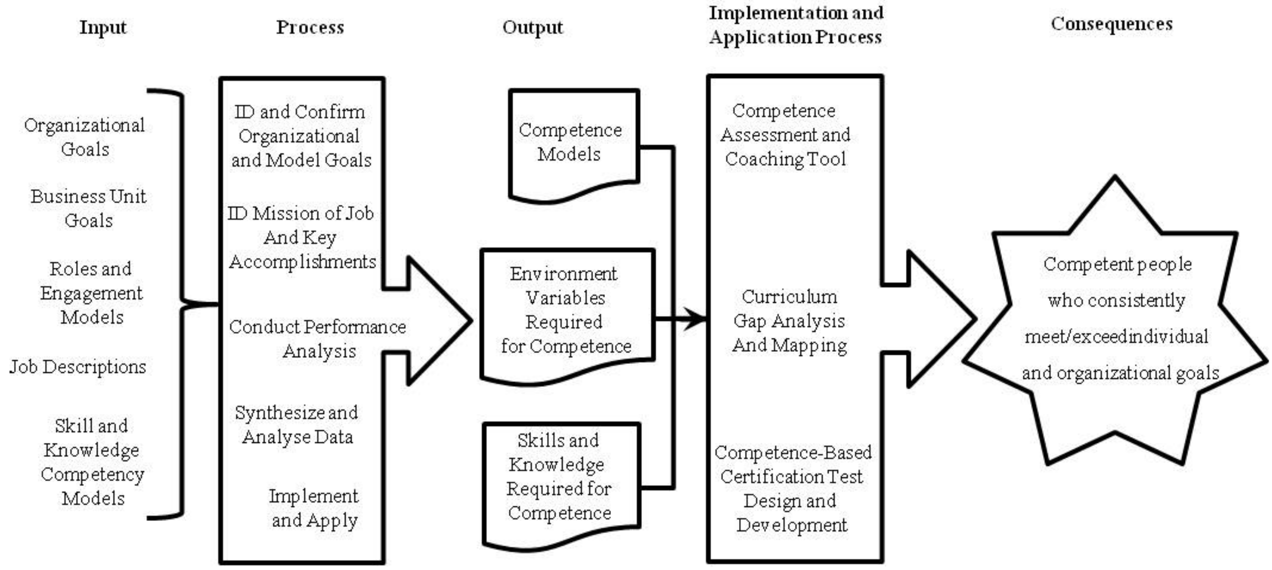

Fig. 1. Teodorescu and Binder's Components and Processes for Building a Competence Model[13]

As can be seen, this definition is in accordance with HPT objectives. Taking the more conventional point of view, AoC can be posited a definition of in line with the HPT definition cited above, dealing with the possession of required skill, knowledge, qualification, or capacity.

The AoC is a conceptual framework assisting practitioners in identifying causes and opportunities, along with the underlying resources and networking them in a hierarchical connection to the corporate vision, and to the success factors in a competitive domain.[26, 27] By assisting competence planning, building a framework ultimately helps avoiding 'competence gaps', defined in terms of a dysfunctional imbalance between skill, knowledge, experience exploration and exploitation. Above all, the proposed integrative framework provides valuable support to practitioners who want to use a decision making approach systematically for competence management. It facilitates the identification of one or several factors with regard to the competence gaps. It also shows where multiple methods or alternatives are available and where more effort is still needed. The framework can thus provide valuable pointers for future development efforts by researchers and practitioners.

Inputs are defined as; organizational and business-unit goals, models of behavior (roles) and skills, job description items. Processes are built to identify and confirm the goals, conduct performance analyses, and so forth. Outputs are; using in the sense of the HPT term, qualifications of the actor (skills and knowledge) and the supportive or destructive environmental variables for the acquisition of the required competence. Competency Models (CM) help us by evaluating and improving of individual and organizational competencies and is a descriptive tool that identifies the competencies needed to operate in a specific role within a job, occupation, organization, or industry. Simply stated, a competency model is a behavioral job description that must be defined by each occupational function and each job.[19, 28] Depending on the work and organizational environment, a group of seven to nine total competencies are usually required of a particular job and depicted in a competency model.[29] To understand competency requirements of a job role, they are often represented pictorially and competencies are mapped, with competencies existing on a hierarchy.[30] In the literature there exist several CM.[31-33] In this paper four models are described for explaining, measuring, and improving the AoC of an organization. These models are:

CM1: Duties, Skills, and Knowledge (DSK) model of competence: This approach is systematic and removes the organizations from the need to address competence in an ad hoc fashion and works equally well for individual and organizational competence. The DSK model implicitly assumes that carrying out the listed duties, possessing the listed skills, and having the listed knowledge is more likely to lead to high-quality architectures.

CM2: Human Performance model of competence; Human Performance model of competence: This model is based on the human performance engineering work of Thomas Gilbert.[25] This model is predicated on the belief that competent individuals in any profession are the ones who produce the most valuable results at a reasonable cost. Developing this model will involve figuring out how to measure the worth and cost of the outputs of architecture efforts, finding areas where that ratio can be improved, and crafting improvement strategies based on environmental and behavioral factors.

CM3: Organizational Coordination model of competence: The focus is on creating an inter-team coordination model for teams developing a single product or a closely related set of products.[34] The organizational structure, practices, and tool environment of the teams allow for particular types of coordination with a particular inter-team communication bandwidth. The coordination model of competence will compare the requirements for coordination that the AoC induces with the bandwidth for coordination supported by the organizational structure, practices, and organizational environment. Competencies not only exist for individual efforts but also for work functions that require team collaboration and coordination. With global competition and technological advances, organizational success is depending more on team efforts. A team competency model is proposed by Margerison[35], with performance being assessed on nine competencies. Finally, a competency framework must be robust, dynamic, fluid, and flexible to change with technological, economic, and other changes[16,17] and should be re-evaluated and refined, along with the selection and other human resources tools developed and used with the competency model.[17,36,37]

CM4: Organizational Learning model of competence.[31-33] This model is based on the concept that organizations, and not just individuals, can learn. Organizational learning is a change in the organization that occurs as a function of experience. This change can occur in the organization's cognitions or knowledge[38], its routines or practices[39], or its performance as presented in Ref. 40. Although individuals are the medium through which organizational learning generally occurs, learning by individuals within the organization does not necessarily imply that organizational learning has occurred. For learning to be organizational, it has to have a supra-individual component.[39]

These are the categories adopted by the International Society for Performance Improvement (ISPI)[41] and come from Ref. 25. Other authors cite anywhere from three to 11 categories, but the principle remains the same; lots of things cause performance problems (or areas for improved performance!). Once these causes are identified, appropriate interventions can be designed and implemented to close the performance gap.

4. Proposed Method for AoC: ANP

4.1. *General Information*

ANP is a generalization of Saaty's Analytic Hierarchy Process (AHP), which is one of the most widely used multi-criteria decision support tools. AHP is limited to relatively static and unidirectional interactions with little feedback among decision components and alternatives.[42] This weakness can be overcome by using the advance multi-criteria making technique, namely the ANP.

Many real life decision problems cannot be structured as a hierarchy because of the fact that they involve the interaction and dependence of higher level elements in a hierarchy on lower level elements. So the hierarchy becomes more like a network (See Fig. 2 where a loop means an inner dependence). On this context, ANP and its super-matrix technique can be considered as an extension of AHP that can handle a more complex decision structure[43, 44] as the ANP framework has the flexibility to consider more complex inter-relationships (outer-dependence) among different elements. ANP is very useful in these kinds of situations providing a general framework without the assumptions of independence of higher-level elements from lower ones, or independence on the same level.[45]

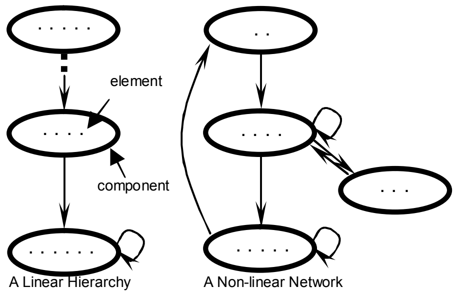

Fig. 2. Structural difference between linear hierarchy and nonlinear network

The ANP models the decision problem with a network structure that relaxes the hierarchical and unidirectional assumptions in AHP to allow the interdependencies in the framework.[46]

The ANP framework has three basic features which are useful in multi-criteria decision-making problems:

- Define the goal and criteria (and sub-criteria),
- Determine the interdependencies and the network and
- Build the supermatrix and synthesizing.

4.2. *Comparison Procedure*

In this approach, comparison matrices, prioritization and the weights while considering the interdependencies are formed between various attributes of each level and filled with the help of Saaty's 1-9 scale by the experts or decision makers.[46] During this phase, decision making for a complex and/or delicate situations often needs a team to work cooperatively to get consensus awareness for the situation.[47]

Once the pair-wise comparison matrices are formed, the consistency of the pair-wise comparisons made by the experts or decision makers have to be checked in order to make the necessary changes if there is any inconsistency above the allowed limit. After that, eigenvectors for all the matrices are calculated in order to define weights of the elements that formed the comparison matrix in question.

The concept of supermatrix is employed to obtain the composite weights that overcome the existing interrelationships. Calculated eigenvectors are placed into the supermatrix.

Assuming we have *n* components, C_j where $j = 1, \ldots, n$, with each one having n_j elements, the supermatrix will be as follows:

$$W = \begin{matrix} & \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} & \begin{bmatrix} W_{11} & W_{12} & \cdots & W_{1n} \\ W_{21} & W_{22} & \cdots & W_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ W_{n1} & W_{n2} & \cdots & W_{nn} \end{bmatrix} \end{matrix}$$

$$\text{where} \quad W_{ij} = \begin{bmatrix} w_{i1}^{j_1} & w_{i1}^{j_2} & \cdots & w_{i1}^{j_{n_j}} \\ w_{i2}^{j_1} & w_{i2}^{j_2} & \cdots & w_{i2}^{j_{n_j}} \\ \vdots & \vdots & \ddots & \vdots \\ w_{in_i}^{j_1} & w_{in_i}^{j_2} & \cdots & w_{in_i}^{j_{n_j}} \end{bmatrix}$$

$$\forall i, j = 1, \ldots, n$$

Here, $w_{in_i}^{j_{n_j}}$ represents the impact of the n_i^{th} element of the component *i* on the n_j^{th} element on the component *j*. Therefore, each column in the matrix W_{ij} is a principal eigenvector that represents the impact of all the elements in the i^{th} component on each of the elements in the j^{th} component.

The supermatrix needs to be stochastic, i.e. the columns have to sum up to one, in order to continue the calculations and obtain meaningful limiting results. For that purpose, we need to compare the components themselves to ensure that. The pairwise comparisons of the components are made with respect to each of the components or according to some attribute presented in a separate control hierarchy for that system. The resulting priorities are used to weight the column vectors of the supermatrix previously obtained. Hence the resulting supermatrix is column stochastic. The overall priority of each element of each cluster and the final ranking of the alternatives are given by the limiting powers of this weighted supermatrix.

4.3. *Case Study*

Organizations may turn to competence architecturing for help to improve their outstanding achievements, as a result of which, evaluation of their competence architecturing performance is of importance for enterprises. An ANP model on competence architecturing evaluation system will be constructed in Super Decision software and ANP theory will be applied to evaluate indices in this system.

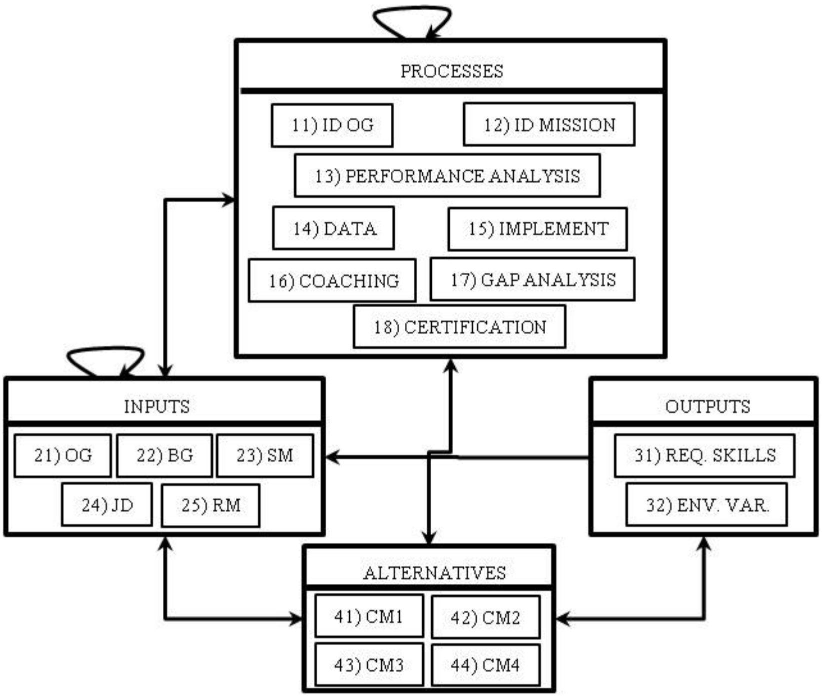

Fig. 3. The Framework of AoC

4.4. *Modeling*

Competence architecturing is complicated, whose synthetic evaluation contents are multi-criteria and multi-alternatives. To construct the AoC evaluation model and to calculate the weights, the software called Super Decisions is used. The Super Decisions software is a simple easy-to-use package for constructing decision models with dependence and feedback and computing results using the supermatrices of the ANP. Refer to AoC essential and its practical situation in organizations, an AoC evaluation model has been constructed in Fig. 3 based on analyzing theories and consulting experts.

4.5. *Obtaining pairwise comparison matrices*

After modeling, paired comparisons under each control criterion are performed. This phase is done by using Delphi method. To make sure the result is more exact and reasonable more experts are expected to participate in pairwise comparison. The elements in a cluster are compared by applying Saaty's 1-9 scales[46] according to their influence on an element in another cluster which they are connected to (or on elements in their own cluster). Inconsistency for each pairwise comparison matrix is also checked. A comparison matrix is considered to be consistent when its inconsistency ratio is less than 0.1.

An example of node comparison matrix and an example of cluster comparison matrix can be seen in Table 1 and Table 2 respectively.

Such comparison matrix as given in Table 1 will be built for each node connected other nodes (more than one) in a cluster. In the case where a node is connected to only one node in a given cluster, a relative priority of "one" will be assigned for the impact of this node on the node of reference.

The relative priorities calculated according to those node comparison matrices will be placed in their appropriate place in the supermatrix (see in Appendix A).

Table 1. Pairwise comparison of nodes in Processes cluster with respect to Gap Analysis

GA	IDO	IDM	PA	D	IMP	CO	CER	w
IDO	-	1/5	7	7	3	5	9	.25
IDM		-	7	7	3	5	9	.427
PA			-	1	1/5	1/3	3	.39
D				-	1/5	1/3	3	.39
IMP					-	3	5	.145
CO						-	3	.074
CER							-	.024
							CR	.075

Table 2. Pairwise comparison of clusters with respect to Inputs

INPUTS	INPUTS	MODELS	PROCESSES	w
INPUTS	-	1/7	1/5	.072
MODELS		-	3	.649
PROCESSES			-	.279
			CR	.06

Such comparison matrix as given in Table 2 will be built for each cluster in the same manner as in node comparison matrices and the relative priorities calculated according to those matrices will be used to form the cluster matrix, given in Table 3, which will be used to obtain the weighted supermatrix (see in Appendix B).

Table 3. Cluster Matrix

	Models	Inputs	Outputs	Processes
Models	0	.649	.875	.242
Inputs	.105	.072	.125	.088
Outputs	.258	0	0	0
Processes	.637	.279	0	.669

With respect to Inputs; as it is seen in Table 4.

- The first three components for CM1 are, in their order, Job description (JD), Skill Models (SM) and Role Models (RM). Developing this model will involve cataloging what employees and organizations do and know, building measures for how well they do and know it, and crafting improvement strategies for their duties, skills, and knowledge. Assembling a comprehensive set of duties, skills, and knowledge for a profession can help us define what it means to be a competent employee.

Table 4. A Portion of Unweighted Comparison Matrix

		41) CM1	42) CM2	43) CM3	44) CM4
Inputs	21)BG	0.06338	0.38986	0.56501	0.28953
	22)OG	0.03333	0.38986	0.26220	0.58309
	23)JD	0.51281	0.15235	0.05528	0.04248
	24)RM	0.12897	0	0.11751	0.08490
	25)SM	0.26150	0.06792	0	0
Comp. Models	41)CM1	0	0	0	0
	42)CM2	0	0	0	0
	43)CM3	0	0	0	0
	44)CM4	0	0	0	0
Outputs	31)Env	0.12503	0.16667	0.75000	0.87500
	32)Req	0.87497	0.83333	0.25000	0.12500
Processes	11)IDO	0	0	0.41284	0.28061
	12)IDM	0	0.51281	0.28207	0.40820
	13)PER	0.51281	0.12898	0.02400	0.02357
	14)DATA	0.26150	0.03333	0	0
	15)IMP	0.03333	0.06338	0.15771	0.15667
	16)COA	0	0	0.08097	0.09141
	17)GAP	0.12898	0.26150	0.04241	0.03955
	18)CER	0.06338	0	0	0

- The first three components for CM2 are, in their order, Business Unit Goals (BG)- Organizational Goals (OG) and Job Description (JD). According to CM2 measuring performance of various activities throughout an organization can to find where the biggest improvements can be made. However, acting on the performance management and measurement may or may not result in economic gain to the organization. It depends on the contribution that activity has to the bottom line. That is, when applying the Human Performance

Technology model to improve employee competence, the focus is mostly on the aspects of the organizational and business unit goals.

- The first three components for CM3 are, in their order, Business Unit Goals (BG)- Organizational Goals (OG) and Roles and Engagement Models (RM). Despite the efforts to assess the competencies associated with personal characteristics, traits and motivation, such competencies are difficult to define and therefore difficult to assess. Such competencies cannot be directly measured in behavioral terms, but more accurately there are behaviors associated with these competencies. Thus, assessments of such competencies are not objective; rather they are based on faulty or interpretable assumptions about behaviors that constitute maturity, flexibility, cooperation, autonomy, and independence, among others. For these competencies, measurements that meet professional standards are needed which are consistent with Organizational and Business Unit Goals.
- The first three components for CM4 are, in their order, Organizational Goals (OG), Business Unit Goals (BG) and Roles and Engagement Models (RM). In general Competency models are being used in other areas of human resources management to align the goals of an organization and talents of its workers. It is important to note that a competency model describes the qualities required of a worker to be successful in a position, on a team, and within an organization, but a competence model describes what an individual worker must perform consistently to achieve or exceed the strategic goals of the organization.[13, 23, 48] In other words, there are competencies required in a job and these can be held by both average and exemplary employees, but there are also competencies held by only the exemplary worker.[16] This latter definition is related to aligning people and their performance to corporate goals, organizational strategy and success, business competitiveness, and profit. Competencies are identified and given importance when they achieve the organization's goals. In Ref. 23 it is explained that the difference between each concept has become fuzzy in both literature and practice. Competency models also are being used to organize the business needs and directional strategy, convey the values and mission of a company, and reward those workers who learn and demonstrate the identified organizational competencies.[17, 19]

With respect to Outputs; as it is seen in Table 4:

- The first component for CM1 is Environment Variables Required for Competence (Env); Skills and Knowledge Required for Competence (Reg). DSK Model it is believed that before addressing the Environmental factors it is most necessary to focus on "Skills and Knowledge Required for Competence".
- With respect to CM2 it is believed that it was the absence of performance support (environment) at work, not an individual's lack of knowledge or skill, which was the greatest barrier to exemplary performance. Therefore, it's believed it was most necessary to focus on variables in the work environment before addressing the individual. Contrary to the CM2 our findings is supporting to focus before addressing the Environmental factors it is most necessary to focus on "Skills and Knowledge Required for Competence" .
- With respect to CM3 it is believed that it was the absence of performance support (environment) at work, not an individual's lack of knowledge or skill that was the greatest barrier to exemplary performance. Therefore, it's believed it was most necessary to focus on variables in the work environment before addressing the individual.
- With respect to CM4 organizational environment plays an important role. Both formal and informal aspects of the organizations environment affect organizational learning. As it is known formal organizational arrangements, such as technology and structure, influence organizational learning and knowledge transfer. But informal aspects of the organizational context, such as culture and social networks, also influence learning processes. Learning processes occur in communities of practice that may cut across organizational boundaries. The volatility and heterogeneity of the environment also affect learning processes and outcomes.

As it is seen in Table 4:

- With respect to CM1 although there is no single definitive or authoritative source for the duties, skills, and knowledge required for competence, there are several organizational processes that we have canvassed to assemble a picture of what an employee and an architecting competency organization must know and do. We ranked the first three categories of processes:

  (i) Conducting Performance Analysis,
  (ii) Synthesize and Analyze Data tell us what organizations in the business need to know ,
  (iii) Curriculum Gap Analysis and Mapping Sources related to "doing profession for a living" tell us what employers are looking for and what employees seeking employment are saying about themselves. The DSK model clearly tells us to evaluate present activity.

- With respect to CM2 We ranked the first three categories of processes:

  (i) Identification Mission of Job and Key Accomplishments,
  (ii) Curriculum Gap Analysis and Mapping. Conducting performance analysis of various activities throughout an organization can help to find where the biggest improvements can be made. However, conducting performance analysis (PER) may or may not result in economic gain to the organization. It depends on the contribution that activity has to the bottom line when applying Human Performance Technology,
  (iii) Conducting Performance Analysis the HPT model clearly tells us to evaluate past performance. Several authors also caution against using competency models for measuring or appraising certain areas of performance and providing developmental feedback based on these assessments.[2, 18, 23, 49] Despite the efforts to assess the competencies associated with personal characteristics, traits and motivation, such competencies are difficult to define and therefore difficult to assess.

- With respect to CM3 the organizational coordination model, in practice, concentrates most heavily on the practice that produces an architecture-conformant implementation, and tells us how effective the organization is likely to be at carrying out that practice. We ranked the first three categories of processes:

  (i) Identification Mission of Job and Key Accomplishments,
  (ii) Identify and Confirm Organizational and Model Goals,
  (iii) Implement and Apply

- With respect to CM4 to improve the process of organizational learning, our findings support the two approaches: identification and communication of Organizational and Business Goals and treat changes in routines and practices in implementations as indicators of changes in knowledge and view changes in organizational performance indicators associated with experience as reflecting changes in knowledge. We ranked the first three categories of processes:

  (i) Identify and Confirm Organizational and Model Goals
  (ii) Identification Mission of Job and Key Accomplishments
  (iii) Implement and Apply

With respect to whole gamut of components, as it is seen in Table 5:

- According to CM1 if Table 5 is analyzed to the whole gamut of the components (not in clusters) and ranked against the first three headings; Conducting Performance Analysis, Skills and Knowledge Required for Competence, Synthesize and Analyze Data are the most important components. This type of Model (CM1) needs competence architecture-centric duties (e.g., establishing a competence architecture review board), skills (e.g., Human Resource skills for adequately hiring, mentoring, and rewarding component employees), and knowledge (e.g., how to assemble the most effective competent teams). Focusing on duties, skills, and knowledge provides an operational way to assess current competence (measure the effectiveness of employees' duties performance, the strength of the skills, and the extent of the knowledge) as well as to predict future competence (measure the skills and the mastery of the knowledge). It also suggests an obvious and actionable approach to improve individual competence: practice the duties, improve your skills, and master the knowledge. In the DSK model, the key to competence lies in the duties, skills, and knowledge of an employee. The greater the employees' ability to carry out the duties and possess the required skills and knowledge, the more able that employee is to demonstrate high-quality performance and hence the more competent. We can assess employee competence according to the DSK model. A successful organization will consider the CM of DSK when selecting and hiring new employees but also will be using the competency model to develop and advance incumbent employees. In some companies, successful succession planning requires updating competency models or job descriptions, recognizing internal talent through assessment, and developing such talent through training.[36] From a human resources perspective and strategic business model[50], this type of competency model can be used to assist people in moving up or over in an organization or industry to benefit an organization. The results of such an assessment instrument can be used to identify areas where needed improvements are indicated. The result shown in Table 5 supports this concept. There are components profiles relevant to DSK Competence Model: such organizations might be motivated to maintain, measure, and advertise their architecture competence as a means of attracting and retaining employees. DSK model, supplies the list of job accomplishments and task steps in the form of duties.

- With respect to CM2 if Table 5 is analyzed according to the whole gamut of the components and ranked again as the first three headings:

(i) Identification Mission of Job and Key Accomplishments
(ii) Skills and Knowledge Required for Competence
(iii) Curriculum Gap Analysis and Mapping

Competency models have their place in human resources practices and their use can be a method of speaking a similar language among various audiences when discussing work requirements. However, competency models are not the sole solution for every hiring and selection decision or other managerial functions[51], nor should they be the only tool utilized in meeting education and training needs.[52]

Table 5. A portion of weighted supermatrix

		41) CM1	42) CM2	43) CM3	44) CM4
Inputs	21)BG	0.00664	0.04083	0.05917	0.03032
	22)OG	0.00349	0.04083	0.02746	0.06106
	23)JD	0.05370	0.01596	0.00579	0.00445
	24)RM	0.01351	0	0.01231	0.00889
	25)SM	0.02739	0.00711	0	0
Comp. Models	41)CM1	0	0	0	0
	42)CM2	0	0	0	0
	43)CM3	0	0	0	0
	44)CM4	0	0	0	0
Outputs	31)Env	0.03229	0.04305	0.19371	0.22600
	32)Req	0.22599	0.21523	0.06457	0.03229
Processes	11)IDO	0	0	0.26297	0.17874
	12)IDM	0	0.32666	0.17968	0.26002
	13)PER	0.32666	0.08216	0.01529	0.01502
	14)DATA	0.16657	0.02123	0	0
	15)IMP	0.02123	0.04037	0.10046	0.09980
	16)COA	0	0	0.05158	0.05822
	17)GAP	0.08216	0.16657	0.02702	0.02519
	18)CER	0.04037	0	0	0

In Ref. 53, it is explained that framing competencies as an outcome can ignore the mental and personal processes that are utilized in developing and exhibiting skills and utilizing knowledge. Some idiosyncratic competencies that can assist a person in being successful in their job or contributing to the competitiveness of an organization may be overlooked if the competency model solely is used to strategically select only staff that fit this model and do not rely on developmental resources to facilitate acquisition of competencies where a gap exists.[54-56] HPT calls for calculating the value or worth of specific job accomplishments so that low-performing areas can be targeted for improvement. Improvement, in turn, depends on identifying the steps involved in carrying out a task.

- With respect to CM3 and CM4 if the ANP Matrices are analyzed according to with respect of the whole gamut of the components and ranked again as the first three headings are (even the order for CM4 is slightly different the components are the same):

(i) Identification Mission of Job and Key Accomplishments
(ii) Identify and Confirm Organizational and Model Goals
(iii) Environment Variables Required for Competence

Similarly, the Organizational Learning model is concerned with how organizations internalize and utilize knowledge. One way organizations do this is by building and nurturing appropriate and effective coordination mechanisms. Testing how well they've done this to achieve an end (in this case, producing high-quality architectures) can be accomplished through HPT methods. In this combination of models, organizational learning is dominant and ―calls the other three to inform it in specific areas. By having the entire organization involved in the development of competency models and defining what certain competencies mean for that particular organization, there will be an organizational expectation of what makes the company succeed. For the gaps in competency acquisition, further training and development can be offered and provided to aid in acquisition of the desired skill, knowledge, behavior, trait, etc. Allowance for some less needed or desired competencies should be considered as well to perhaps enrich the talent pool. For occasions when these competencies are not developed, it is likely that inaction or an ineffective behavior may prevent the worker from accomplishing job tasks and organizational goals. While not usually the most cost-effective option for businesses after investing in an employee, it may be most appropriate for the company to re-evaluate the current competencies of an individual and his or her acquisition for learning new and desired competencies based on those competencies required of the organization. With the results of this analysis, the organization and individual can determine the individual's future within that organization. The employee might benefit far greater in the long run knowing that other organizations within that industry or across industries would be a better career fit.

4.6. *Calculate the priorities of the criteria*

The Super Decisions software can provide the priority vector for the alternatives in the subnets when pairwise comparisons are done and give the synthesized priority vector for the alternatives over all the subnets when the calculations are done in the control network. The total weights of the alternatives are showed in Table 6.

From Table 6, it can be concluded that the best alternative for the case Company (a leading innovation driven company) is the CM4 and the worst is the CM1 and that the final ranking for the alternatives is as follows:

$$CM4 \succ CM3 \succ CM2 \succ CM1$$

Table 6: The total weights of Alternatives

Alternatives	Total	Normal	Ideal	Ranking
41) CM1	0.0328	0.1124	0.2595	4
42) CM2	0.0356	0.1223	0.2822	3
43) CM3	0.0967	0.3320	0.7663	2
44) CM4	0.1262	0.4333	1.0	1

5. Conclusions

As noted above, with certain exceptions considered, architecturing competency models are a viable tool that can be utilized to prepare the current and future workforce and retain skilled current workers to meet the job requirements and other needs of employers.

Organizations can evaluate more exactly and more rationally their competence architecture with the presented ANP methodology in this paper. This paper demonstrated how ANP in particular can be used within AoC context to integrate significant existing knowledge in HPT research into a multi-criteria model for competence mapping decisions.

The ANP approach provides a richer multidimensional perspective for understanding competence mapping decisions in a particular situation. Possible future work includes research on applying the proposed model to different organizational settings and gathering the reflections of the stakeholders on such interventions. Hence our starting assumption that it is sufficient to model the problem as an ANP model might be a limitation of our work reported here which however should be addressed by investigating in the future the appropriateness of its relevance. This possibility requires further field applications and comparisons between theoretical and practical ANP application models for competence mapping decisions.

In addition, usage of Super Decision, user-friendly software, makes the decision making process by using ANP easier. An example is also presented to illustrate the proposed method with applications thereof. The results show the proposed method is suitable and effective in real-world applications.

The model developed in this paper has a limitation as well: the results reported in this research are based on the opinion of the decision-makers, whose preference to some criterion might have influenced the results. Although Delphi method is used in pairwise comparison phase, some subjective factors are still inevitable. At present, it is subject to an ongoing revision, and the underlying dimensions are regularly checked, and eventually refined against the addition of further elements. Moreover, in future research, we will perform surveys among decision-makers, in order to assess to which degree the competence architecture really support the processes indicated in the framework. Some other approaches for group decision making, as in Ref. 57; or for the determination of the criteria weights as in Ref. 58 can also be proposed and used for that purpose.

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Appendix A. Unweighted Supermatrix

	21)	22)	23)	24)	25)	41)	42)	43)	44)	31)	32)	11)	12)	13)	14)	15)	16)	17)	18)
21)	0	0	0.10492	0.36135	0.36135	0.06338	0.38986	0.56501	0.28953	0	0	0	0.26149	0.90000	0.73064	0.60215	0.83333	0.21092	0
22)	0	0	0.05394	0.57361	0.57361	0.03333	0.38986	0.26220	0.58309	0	0.90000	0.90000	0.51282	0.10000	0.08096	0.25389	0.16667	0.08414	0
23)	0	0	0	0.06504	0.06504	0.51281	0.15235	0.05528	0.04248	0	0.10000	0.10000	0.12898	0	0.18840	0	0	0.70494	0
24)	0	0	0.24901	0	0	0.12897	0	0.11751	0.08490	0	0	0	0.03333	0	0	0.08259	0	0	0.12503
25)	0	0	0.59213	0	0	0.26150	0.06792	0	0	0	0	0	0.06338	0	0	0.06137	0	0	0.87497
41)	0.05528	0.05529	0.56501	0.05703	0.05529	0	0	0	0	0.04249	0.56501	0.04651	0.04853	0.56501	0.04249	0.04651	0.04249	0.04249	0.64575
42)	0.11751	0.11750	0.26220	0.12218	0.11750	0	0	0	0	0.08489	0.26220	0.10936	0.10145	0.26220	0.08489	0.10936	0.08489	0.08489	0.22998
43)	0.56501	0.26219	0.11750	0.29762	0.56501	0	0	0	0	0.28952	0.11750	0.55123	0.24271	0.11750	0.28952	0.55123	0.28952	0.28952	0.08355
44)	0.26220	0.56502	0.05529	0.52317	0.26220	0	0	0	0	0.58310	0.05529	0.29290	0.60730	0.05529	0.58310	0.29290	0.58310	0.58310	0.04071
31)	0	0	0	0	0	0.12503	0.16667	0.75000	0.87500	0	0	0	0	0	0	0	0	0	0
32)	0	0	0	0	0	0.87497	0.83333	0.25000	0.12500	0	0	0	0	0	0	0	0	0	0
11)	0	0	0	0	0	0	0	0.41284	0.28061	0	0	0	0.73064	0.04509	0	0.18839	0.18839	0.25064	0
12)	0	0	0	0	0	0	0.51281	0.28207	0.40820	0	0	0.73064	0	0.11023	0	0.73064	0.73064	0.42730	0
13)	0	0	0.63699	0	0	0.51281	0.12898	0.02400	0.02357	0	0	0	0	0	0	0	0	0.03943	0.25828
14)	0	0	0	0	0	0.26150	0.03333	0	0	0	0	0	0	0.27122	0	0	0	0.03943	0
15)	0	0	0.25828	0	0	0.03333	0.06338	0.15771	0.15667	0	0	0.08096	0.08096	0	0	0	0.08096	0.14536	0.10473
16)	0	0	0.10473	0	0	0	0	0.08097	0.09141	0	0	0	0	0	0	0.08096	0	0.07431	0
17)	0	0	0	0	0	0.12898	0.26150	0.04241	0.03955	0	0	0.18840	0.18840	0.57347	0	0	0	0	0.63699
18)	0	0	0	0	0	0.06338	0	0	0	0	0	0	0	0	0	0	0	0.02352	0

Appendix B. Weighted Supermatrix

	21)	22)	23)	24)	25)	41)	42)	43)	44)	31)	32)	11)	12)	13)	14)	15)	16)	17)	18)
21)	0	0	0.00755	0.03605	0.03605	0.00664	0.04083	0.05917	0.03032	0	0	0	0.02300	0.07915	0.19438	0.05296	0.07329	0.01855	0
22)	0	0	0.00388	0.05722	0.05722	0.00349	0.04083	0.02746	0.06106	0	0.11253	0.07915	0.04510	0.00879	0.02154	0.02233	0.01466	0.00740	0
23)	0	0	0	0.00649	0.00649	0.05370	0.01596	0.00579	0.00445	0	0.01250	0.00879	0.01134	0	0.05012	0	0	0.06200	0
24)	0	0	0.01791	0	0	0.01351	0	0.01231	0.00889	0	0	0	0.00293	0	0	0.00726	0	0	0.01100
25)	0	0	0.04259	0	0	0.02739	0.00711	0	0	0	0	0	0.00557	0	0	0.00540	0	0	0.07695
41)	0.05528	0.05529	0.36676	0.05134	0.04977	0	0	0	0	0.04249	0.49436	0.01128	0.01177	0.13709	0.03118	0.01128	0.01031	0.01031	0.15668
42)	0.11751	0.11750	0.17020	0.11000	0.10578	0	0	0	0	0.08489	0.22942	0.02653	0.02462	0.06362	0.06231	0.02653	0.02060	0.02060	0.05580
43)	0.56501	0.26219	0.07627	0.26793	0.50865	0	0	0	0	0.28952	0.10281	0.13374	0.05889	0.02851	0.21250	0.13374	0.07025	0.07025	0.02027
44)	0.26220	0.56502	0.03589	0.47098	0.23605	0	0	0	0	0.58310	0.04837	0.07106	0.14735	0.01341	0.42797	0.07106	0.14147	0.14147	0.00988
31)	0	0	0	0	0	0.03229	0.04305	0.19371	0.22600	0	0	0	0	0	0	0	0	0	0
32)	0	0	0	0	0	0.22599	0.21523	0.06457	0.03229	0	0	0	0	0	0	0	0	0	0
11)	0	0	0	0	0	0	0	0.26297	0.17874	0	0	0	0.48911	0.03018	0	0.12612	0.12612	0.16779	0
12)	0	0	0	0	0	0	0.32666	0.17968	0.26002	0	0	0.48911	0	0.07379	0	0.48912	0.48912	0.28605	0
13)	0	0	0.17769	0	0	0.32666	0.08216	0.01529	0.01502	0	0	0	0	0	0	0	0	0.02640	0.17290
14)	0	0	0	0	0	0.16657	0.02123	0	0	0	0	0	0	0.18156	0	0	0	0.02640	0
15)	0	0	0.07205	0	0	0.02123	0.04037	0.10046	0.09980	0	0	0.05420	0.05420	0	0	0	0.05420	0.09731	0.07011
16)	0	0	0.02922	0	0	0	0	0.05158	0.05822	0	0	0	0	0	0	0.05420	0	0.04974	0
17)	0	0	0	0	0	0.08216	0.16657	0.02702	0.02519	0	0	0.12612	0.12612	0.38389	0	0	0	0	0.42642
18)	0	0	0	0	0	0.04037	0	0	0	0	0	0	0	0	0	0	0	0.01574	0

Appendix C. Limit Supermatrix

	21)	22)	23)	24)	25)	41)	42)	43)	44)	31)	32)	11)	12)	13)	14)	15)	16)	17)	18)
21)	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577	0.02577
22)	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006	0.04006
23)	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253	0.01253
24)	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398	0.00398
25)	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328	0.00328
41)	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276	0.03276
42)	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563	0.03563
43)	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673	0.09673
44)	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624	0.12624
31)	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986	0.04986
32)	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539	0.02539
11)	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796	0.16796
12)	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114	0.20114
13)	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151	0.02151
14)	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197	0.01197
15)	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340	0.05340
16)	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910	0.01910
17)	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026	0.07026
18)	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243