Using Competence Modeling to create Knowledge Engineering Team

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Abstract. The present paper is about applying competence modeling for a knowledge engineer in the case of the company WBSA Sistemas Inteligentes S.A. The process was based on Lucia and Lepsinger model, by which competences are characterized through the identification of situations and behaviors considered relevant to the engineer performance. As one of the different techniques suggested by the model for collecting data, a number of individual interviews were undertaken and at the end it was defined and validated a set of eleven competence regarded as necessary for a satisfactory performance of a knowledge engineer.

Introduction

Knowledge-based systems (KBS) are computer programs that use explicitly represented knowledge to solve problems. Such systems handle knowledge and information by an intelligent manner and are used to solve problems that require a high volume of specialized knowledge [1].
To build a knowledge-based system implies to create a computational model with the objective of developing the capability of solving problems similar to the capability of a domain specialist [2].
In this context, the Knowledge Engineer plays an essential role since he will be the actor responsible for sharing with the specialists his procedures, strategies, and practical rules to solve problems and for building that knowledge into an intelligent system. When this process is correctly performed the result is a system that provides solutions similarly to a human specialist.

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The objective of this paper is to present the competence modeling process for the Knowledge Engineer, identifying the set of knowledge, skills, and attitudes required for a high performance of the engineer.

1 The Concept of Competence

Due to the diversity of knowledge domains where the concept of competence is applied, it is acceptable that there is no consensus about its definition. That is true even in the context of management.

According to Woodruffe [3], at the center of the debate about management a sensitive field is found where the term competence brings a different meaning when used by different people.

Ruzzarin, Amaral and Simionovisci [4] say that there is no doubt that the concept of competence is at the same time one of the concepts most commonly used and one of the most controversial one in the modern language of management.

Currie and Darby stated that the concept became popular due to Boyatzis, who defined competence as the characteristics of a person that can be observed and can be expressed in terms of motivation, skills, and aspects related to his image or role or the amount of knowledge.

Despite the historical importance of the concept presented by Boyatzis, it is considered too broad and its usage is limited to the field of organizational management. More objective definitions as the one presented by Parry [6] become more commonly used. Parry defines competence as a set of knowledge, skills, and attitudes that mostly affect a work, and keep a relation with the performance; they can be measured through some accepted tools and can be improved by training and development.

As per Cooper [7], the four criteria presented by Parry should be used when defining the profile of competence inherent to a function or a position. Given that any characteristic not included in those criteria should be excluded from the definition of a profile, from the set of factors defining a competence the author eliminates personality traces, capabilities, abilities and attitudes.

Contrary to the approach of Cooper, for Lucia and Lepsinger [8] characteristics as attitudes and capabilities are important for the success in some specific positions, although they having a more subjective character. Another relevant aspect is that even characteristics not so easily quantifiable can be measured and evaluated when translated into behaviors.

The approach based on behaviors was first developed by McClelland and shows wide acceptance by models used nowadays, because "it is only through their behaviors that human beings affect the context where they act" [9].

In line with this perspective, Lucia and Lepsinger suggest that the definition of a competence can be represented in a similar way to a pyramid, the pyramid of competences. As shown by Figure 1, at the top are the behaviors and the base, which provides support to the behaviors, is structured by the skills, knowledge, abilities, and personal characteristics.

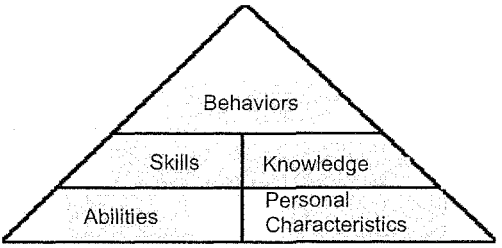

Fig. 1 – Pyramid of competences - Lucia and Lepsinger (1999)

This paper is based on the concept of competence presented by Lucia and Lepsinger. It is considered more adequate because it takes into account attitudes and other subjective, personal characteristics as part of competence.
Furthermore, the chosen model turns possible to measure and evaluate those components of competence due to the fact that it uses the approach based on behaviors to describe competences.
On the other hand, the concept proposed by the above mentioned authors keeps compatibility to the work of Parry and McClelland, which are regarded as important references in the field of management based on competences.

2 Competence Modeling

As stated above, the present paper keeps coherence with the concept of competence proposed by Lucia and Lepsinger. Three steps are considered when applying the model: planning, development, and finalizing and validating the model.

2.1 The case study

2.1.1 The Company

WBSA Sistemas Inteligentes S.A. was created in the context of the knowledge era. It is an Information Technology company in line with the worldwide *avant-garde* in terms of applying artificial intelligence techniques to information systems.
The origin of the company is strongly linked to university post-graduate programs, still maintaining academic and research partnership with them.
Years of research and development efforts undertaken by WBSA team consolidated the excellence of its intellectual capital, which is recognized worldwide through more than fifty papers already presented and edited by international conferences.
The company developed its expertise in providing solutions based on artificial intelligence techniques for knowledge management systems. In this regard WBSA is recognized by the Brazilian Software Companies Association (ABES) for having well-known specialization.
WBSA stated as its mission "to provide the best intelligence resources applied to the use of information".

2.1.2 The Working Process

With the aim of applying the competence modeling for the company, the first step was to prepare the map of processes undertaken by WBSA. It consists of

understanding the processes, detailing activities, and collecting information about inputs and outputs [10]. Figure 2 shows the company's workflow.

Fig. 2 – Processes in WBSA

2.1.3 The Position of Knowledge Engineer

The term Knowledge Engineering is used to describe the whole development process of knowledge-based systems. It is part of the process a special way of interaction between the system developer, called the knowledge engineer, and one or more specialists on the knowledge domain [11].

In the past, knowledge engineering was the process of transferring knowledge from the specialist into the system knowledge base. That approach normally caused failures because it is not possible for the specialist to translate into words all the knowledge involved in his task [12].

The objective of the knowledge engineering process is to capture the knowledge of a domain specialist, as well as his forecast and control procedures on the subject. This process involves becoming familiar with the domain, to collect information, to do analysis and evaluate the effort required by the project. Furthermore, the knowledge being accumulated has to be codified and tested; the scope of work has to be defined, establishing exactly what the user requires to be efficiently retrieved; the quantity and quality of documents have to be analyzed; and the construction of the vocabulary to support the retrieving process.

2.2 Applying the model

2.2.1 Planning

The definition of the objectives and scope of the project took as reference the analysis of the critical organizational process with the aim of establishing a competence model for a relevant position in the organization.

Given the importance of the role of the knowledge engineer for the success of the system implementation phase, the knowledge engineering process was elected as a critical process for the Company. And the position of knowledge engineer was chosen to apply the model.

Afterwards the expected result of the project was discussed and the different phases and activities were described.

2.2.2 Development

Data Gathering: was done through individual interviews with the three professionals working as knowledge engineers in the organization, following the questionnaire proposed by Lucia and Lepsinger.
Situations and behaviors observed along the interviews and used as reference for identifying knowledge, attitudes, and skills required for a knowledge engineer are shown on Tables 1, 2 and 3.
The three interviewers produced separate tables with their own observations, which were then evaluated to form a consensus about the internal competence model. Each one of the items included in the competence model (knowledge, skills, and attitudes) was clearly defined and the result is shown on the Tables.

2.2.3 Competence Modeling

Table 1. Knowledge required for a knowledge engineer

KNOWLEDGE	DEFINITION	INTERVIEW EVIDENCE
Business modeling	To know how to apply techniques for users interaction with the aim of understanding the problems of the organization and identifying potential improvements as part of the system requirements.	To define the needs and knowledge required by the client to improve his tasks
Requirements analysis (system modeling)	To know how to use techniques to establish the requirements for the system development	To work in the system development, in data and user's expectations gathering, and to pass it on to the development team
Organizational context analysis methodology	TO know how to use techniques and tools for understanding the organization context, process, personnel and technologies mapping	Organization context: mapping of processes, people, functions, and existing technologies to identify opportunities of implementing technology
Knowledge representation alternatives	In the context of Artificial Intelligence, to represent knowledge means to make it explicit in such a way that a system can understand and take decisions close to what a specialist would do	Knowledge organization / non-structured documents. To implement knowledge representation in the form of ontologies. To organize content in the form of ontologies
The use of ontologies editor and Word extractor	The ontologies editor and the extractor are tools developed to facilitate the process of extracting, organizing, and representing the knowledge involved in the process of developing an intelligent software	The use of technological tools: extractors and search engines
Framework and system functions	Understanding the product to be offered to the user is essential in the process of business prospects. Communication is facilitated when one knows the limits of the proposal, the implementation timeframe and the complexity of the system features	Understanding technology: not how to program, but to know how the system works and what is the role of ontology. Identifying interfaces that provide answers to the client needs. To understand the functions of the tool.
Basic informatics and searching tools	Office and searching tools are used to produce reports, proposals, manuals, presentations, and research about the client domain on the Internet	Searching the Internet (Google, clients sites, bibliography, Word, PowerPoint, Excel, Extractors)
Project management	Set of concepts, techniques, and tools required for project planning and control	Follows the development work related to the client expectations fulfillment
Interpersonal relationship	Set of techniques used to facilitate the	To interact with the client for

KNOWLEDGE	DEFINITION	INTERVIEW EVIDENCE
techniques	contact and communication with other people or groups	establishing empathy and knowledge exchange
Conflicts solving techniques	Techniques and methodologies required for negotiation and mediation	Ontologies delivered did not keep coherence with the subject. Absence of knowledge sharing
Interview methodology and document analysis	To know interview techniques and content extraction techniques	Interview and document analysis. TO extract the clients reasoning

Table 2. Skills of a knowledge engineer

SKILLS	DEFINITION	INTERVIEW EVIDENCE
Systemic vision	To see more than just specific and technical subjects, analyzing all the aspects involved in the system development	To interact with all and everything, in line with the company's strategy. Possibility of systemic vision
Facility of synthesis	Capacity of resuming and detecting the priorities for	To develop efficient knowledge transfer mechanisms. To identify tasks of the specialist that can be done with the tool. Resuming and defining concepts for the system
Facility for systemic thinking	To classify information and actions according to its importance and influence in the system planning	Support material production (manual, guide books, ontologies)
Leadership	Capacity of leading people or group of people to accept ideas and to work for a common objective	If the client does not understand the importance of his participation, it can be harm the system development
Organization	Capacity of organizing his own work, promptly solving problems or delegating what is urgent	Absence of process formalization can be the reason for a bad development process. To develop efficient mechanisms for knowledge transfer
Capacity to take decisions	To do the best choice of alternatives, analyzing the opportunity and viability of the decision	Increase in the perception of defining priorities
Team working	Capacity of interacting with the group to become influent and accept influence	To improve processes performed collectively. To work in synchronicity doing group meetings and disseminating knowledge
To work under pressure	To develop the work under urgency, maintaining emotional equilibrium and behavior	Due to short timing used only two persons to construct ontologies. Need of negotiating the term period
Capacity of moderation and negotiation	Capacity of maintaining good understanding, consensus, and action to pursue common objectives	Interface between the client and system developers. Not enough contact with the client and lack of scope of work
Influence	Capacity of influencing and leading people to attain a common objective	If the client does not understand the importance of his participation, it can be harm the system development. Contact with the client to obtain his agreement
Communication skills	To present ideas in a clear, objective and consistent way, respecting the audience and making sure the message was understood	To work in synchronicity doing group meetings and disseminating knowledge. Communication ability

Table 3. Attitudes of a knowledge engineer

ATTITUDES	DEFINITION	INTERVIEW EVIDENCE
Patience	Listen, listen, listen... keeping good humor	capacitation of specialists who will help to define the system
Curiosity /	Professional growth and development,	To identify clients needs and to define system

ATTITUDES	DEFINITION	INTERVIEW EVIDENCE
Researcher profile	with authonomy and seeking an adequate way of improving knowledge	functions. To obtain knowledge from the client
Proactivivity	To start working by his own and influencing the course of action	To work intuition / action
Sociability	Interact with different groups preserving its individuality, cooperating and exchanging experiences with the group.	Interact with everything and everybody.
Communicability	Take part actively in meetings, asking, informing and answering.	Assure a apt team for a continuous ontologies development work. Continuous sharing (basic premise)
Flexibility	Experiment, accept and adapt easily to new situations related to the work.	Interact and solve communication problems. Necessity of interaction with clients, developers and commercial department.
Creativity	Present new patterns, ideas and innovative solutions in the development of systems.	Identify specialist's tasks that the tool may perform. Construction of support material (manuals, reports, ontologies).
Diplomacy	Ability to present him/herself in a manner in which the relationships are kept in a higher degree of respect, pursuing associations and consensus in difficult situations.	Interact with the client to establish a empathy process and knowledge exchange. Make the developer understand what the client wishes and make the client understand the developer.
Responsibility	Assure that his/her action transmits confidence to the others, keeping them tranquil.	New discussions about the process and restarting. Convince the client is a challenge.
Determination	Keep focus to reach the defined goal, overwhelming eventual difficulties.	Feeling of satisfaction by the client and the Knowledge Engineer, giving the idea that the path chosen was the correct one.
Compromise	Show availability, assuring that the collective results will be reached.	Follow the development of the systems. The lack of compromising must be avoided.

2.3 Finalizing and validating the model

During this phase, the internal competence model was presented to a group of people working in the same environment, but not in the same position, with the aim of doing an analysis of the general model and identifying those competences regarded as essential for the performance of the knowledge engineer.

Since the knowledge engineer interacts with most of the other people working in the company, it was not difficult to form the focus group to discuss and validate the model.

As presented on Tables 1, 2, and 3 there were identified thirty-three competences, from which eleven is the number of knowledge abilities, eleven are skills, and eleven are attitudes.

With the output of the evaluation phase, a focus group discussion was conducted with the objective of refining the model. The result presented on Table 4 shows a list of competences regarded as being essential for a satisfactory performance of a knowledge engineer in the context of the company WBSA.

Table 4. Essential competences of a knowledge engineer

Knowledge	Skills	Attitudes
Ways of knowledge representation. The use of ontolies editor and extractor. Framework and system functions. Basic informatics and searching tools	Communication skills Team working Organization Systemic vision	Diplomacy Communicative Curiosity / Researcher profile Responsiveness

It was verified that, based in the studies about Competences Modelling, the best practice is to identify 5 to 9 competences for each function. That was the goal during this phase, but the conclusion was that, because of the complexity in performing the function, it became crucial to consider the set of competences listed in table 04.

Validate the model and determine the correlation of the competences with the best performances: As this model is being constructed to allow the training and development of the Knowledge Engineers, the application of this phase in the model (a 360° evaluation) was not necessary. The evaluation made in the precedent phase was enough to identify the competences that assure the good performance of the evaluated function.

Finalizing the model: Considering the complexity of the position being analysed, it is understood that the competences identified by the focal group are actually those that must be worked essentially in all Knowledge Engineers of the company. However, the other competences surveyed in the precedent phase (temporary model).

So, it is considered that the competences identified as essential must be searched for the position of Knowledge Engineering; the other may be worked by the company in its training processes and developments, aiming at the improvement and ideal performance of its collaborators.

Conclusions

The position of Knowledge Engineer is relatively new, beginning with the emerging of expert systems in the 80's. With the evolution of the knowledge based systems the position changed its characteristics considerably. So, the establishment of the competences was very interesting as it wasn't a position with consolidated characteristics as opposed to a traditional position.

This research established the competences necessary to the position of Knowledge Engineer in the company WBSA Sistemas Inteligentes SA using Lucia's and Lepsinger's model.

Following the model proposed by the above mentioned authors, the competence modelling may start from a list of competences previously established or from a new one, specifically for the position. In this work, because of the particularities of the position, the second option was adopted.

In the application of the model, some phases were not performed or were adapted, aiming a satisfactory development of the work.

The choice of the position was made taking as reference the mapping of processes and the concept of critical organizational processes.

In this sense, interviews where made with collaborators that occupy this position in the company, and a provisory model of competences was established and lately validated by a broader group. A relevant question diagnosed in the process was the difficulty in differentiate the abilities and attitudes related with the competences identified.

At the end of the process the twelve essential competences to the satisfactory performance by the Knowledge Engineer were established and defined. This list will be initially used in the training and development activities, and may be

lately expanded for the other activities of the process of human resources management.
Beyond the benefit related with the competences modelling, other positive aspect of the application of the model was the reflection exercise made during the interviews about the role of the Knowledge Engineer in the context of the company. This reflection was useful as the company had already worked in the formalization of its responsibilities.

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