The Method of Employee Competencies Management Based on the Ontological Approach

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Abstract. The company's management is based on a set of management decisions in various fields. Effective competency management in the company allows you to make the most appropriate decisions on any issue related to the selection and appointment of the main project executives or a specific job assignment. Ontologies simplify this process and help objectively choose the right employee based on their actual knowledge, skills, abilities, and also allow you to take into account various additional conditions. This paper presents an original method developed by the authors for managing the competencies of employees to make managerial decisions when choosing the best performers for specific projects and job assignments. The process of collecting and managing competencies is considered as a key element in making managerial decisions, the basic concepts regarding this topic are determined, an analytical review of studies is presented, and a method is proposed that can be implemented in the competency management model presented in authors' previous studies and research.

Keywords: Ontologies · Competencies · competency management · Knowledge base · Ontological approach · Management tasks.

1 Introduction

Competence is one of the most important concepts for any modern organization or industrial enterprise. In response to the need to promote continuous improvement and flexibility in staffing in the 1980s, a competency model emerged. Instead of comparing the activities of the employee with pre-defined work activities, this model made it possible to qualify a person on the basis of the competencies he actually possesses. Torkkeli and Tuominen (2002) define competencies as opportunities related to the subject's ability to use his resources [?]. Tobias and Dietrich (2003) represent competency as a set of personal characteristics (knowledge, skills, abilities) that are relatively stable in different situations [?]. Competencies expand the idea of an employee as a key element of the company. The same knowledge or skill may be included in different competencies, given

that competencies have a complex structure, appropriate tools for working and accounting for competencies are required, which should ensure their effective and transparent management. The elimination of errors in the selection and appointment of appropriate employees for specific positions or determining the personnel of the performers of specific projects of the enterprise must be ensured. Managers should have a clear idea of the potential and capabilities of the selected employees to solve specific work tasks and projects. The ontological approach, accounting and competency management allows this to be done with a higher degree of objectivity. In this case, one doesn't have to figure out why the appointed qualified employees did not cope with a particular job or project. And the answer generally is not complicated: the selected staff did not have the necessary competencies. In addition, the proposed approach allows, based on the analysis of missing competencies, to determine individual learning paths and develop the necessary knowledge, skills.

Obviously, today the company management is closely related to accounting and competency management. It should cover all processes that are involved in the production, implementation and development of specific competencies, including their identification, identifying gaps, filling gaps with the help of training sources, coaching and other types of corporate education. Competency management is also one of the elements of personalized corporate training as it allows employees to identify gaps in knowledge and skills, as well as gain new competencies.

Competency management requires a holistic structured approach, namely, a model developed by specialists that meets all the requirements of a modern company. Jorge Luis Victoria Barbosa, Marcos Ricardo Kich et al. (2015) in their work compare different competency management models, such as MCSWILK, HRCSystem, MCGA and MASEL, and also offer their DeCom model, which takes into account the location of employees and information about training events [2]. In all of these models, improvements are possible regarding information on the level of competencies and the conditions for their use. In general, the main functions performed by the competency management model are the formation of a competency map in a company and support for corporate education. Using the proposed method, the set of conditions is expanded, with which you can detail the requests for management decisions, it is also possible to monitor competencies, thereby controlling their availability and updating through corporate educational programs.

2   Materials and methods

Using ontologies allows one to apply modern experience, accelerate the processes of information interaction, save time and other resources, uniquely fix all the basic concepts and definitions, and eliminate ambiguity and duplication of information. The application of the ontological approach in knowledge management systems provides great opportunities for the analysis of available information. The combination of ontologies and workflows within the company allows you to

create an intelligent management system based on the knowledge of the company. D.V. Alexandrov, N.N. Zhebrun (2007) in their work propose using an ontological approach to create a business process management system for an enterprise [1]. This kind of system allows you to use all the accumulated and formalized experience in managing the organization. An environment is being created that provides the creation of a network corporate information technology space [10]. This approach allows one to share common knowledge, reuse it together and create a single information field for managing both company's internal and external processes. Sarma Cakula and Maija Sedleniece (2013) show in their work the use of an ontological approach for knowledge management and the organization of personalized e-learning [3]. The availability of that kind of information allows one to control the competencies' distribution in the company and restore their lack. The objective of this study is to use the most flexible ontological model focused on corporate learning. In order to do this, the ontological model presented below was developed, which is presented in Fig. 1.
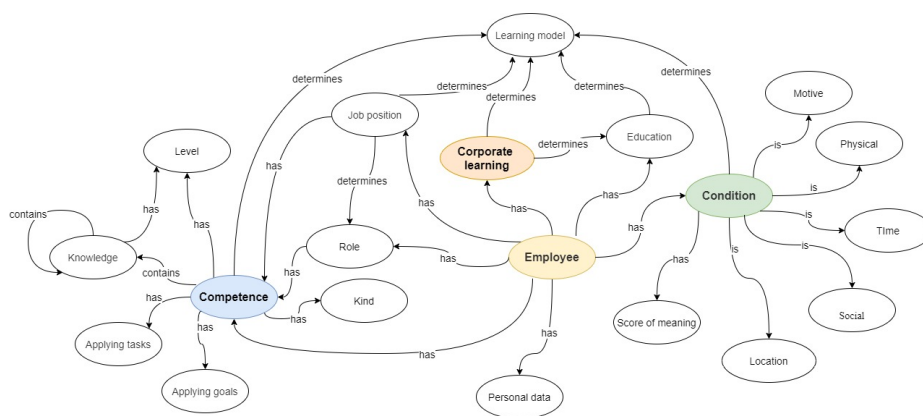

Fig. 1. Ontological model of accounting competencies in the learning process

Each employee has the competence, which is assigned the value of "Level", based on testing and interviews conducted in the company, as well as conditions for work and training are determined. Each of the conditions is assigned a semantic value "Score of meaning", which is used in further calculations and analytics.

Many modern studies show the relevance of understanding the context not only in the learning process, but also in the performance of work tasks. In addition to the set of competencies for each employee, it is possible to determine a set of conditions in which it can be applied. In their work, M. Harzallah and F.B. Vernadat (1999) report that the context in which competence is used is crucial and that the same competence can be used to achieve different goals and objectives [4]. The context of competence is related to the area in which it is ap-

plied. It presents the conditions and limitations in which competency should be used. Also, the meaning of context is mentioned in the work of Sergio Miranda, Francesco Orciuoli, Vincenzo Loia, Demetrios Sampson (2017) [6]. The context for the application of competence is important in the competency management model they have presented. Conditions are also an essential component of the DeCom model presented by Jorge Luis Victoria Barbosa, Marcos Ricardo Kich et al.(2015) [2].

Context allows one to consider competency as a complex component and include various parts. One competency can be invested in another and at the same time created as a result of a request consisting of several competencies and conditions. For example, knowledge of the English language may have the conditions for its use: in business negotiations, when studying technical documentation, when working with specific vocabulary. These conditions require additional clarification as to whether the employee is ready to take on additional responsibilities or change the scope of activities. If the combination of conditions and competence becomes permanent, then it becomes the new competency necessary for the company, by which a template request is generated.

In order to solve any management problem, one needs to correctly determine the input data and what is necessary to look for as a result. The human factor plays a great role in this case [6]. But information technology can help, if not completely, but partially. The conditions for work and the task that must be solved are determined by the company and the current circumstances. Company executives decide what kind of employee is needed: manager, programmer, food industry technologist, and then determine further search parameters for the right employee [8]. But it happens that the problem needs to be solved suddenly and then there is no time to hire a new employee, it is necessary to choose from those who currently work in the company and are competent in the question posed or are ready to perform certain tasks.

3 Employee competency management method

Competency management includes creating a competency map, regulating the needs for competencies, identifying gaps and filling them with sources of training, coaching and other corporate educational activities. Competencies relate to synergy, integration, and interaction between technology, people, organizational systems, and culture. Therefore, information technology is a key resource in helping managers map and develop competencies in the context of the current and strategic objectives of the company.

The first point on the way to solving this problem is its formulation and description. At this stage, it is important to determine the set of conditions and the necessary competencies for its solution and form a request. Next, one needs to identify employees who meet the specified requirements, and then finds out the conditions in which employees with the necessary competencies are ready to work. To do this, it is proposed to calculate the compatibility result for this situation. To calculate this result, we use an approach based on the theory of

fuzzy sets. Having received the value for each of the selected employees, it is necessary to compare them with the reference value specified earlier. For example, if as a result of calculations we get the value 0.87, and the set threshold is 0.8, then the employee is suitable for solving the problem [6]. Using this algorithm, we can calculate the values for all employees for each competency and various additional conditions.

The function that describes this action is represented as follows:

$$P(c) = \sum_{i=1}^{n} w_i \mu_i(c_i) \tag{1}$$

where μ_i – is the membership function.

Thus, the solution to the management problem is modeled by defining a set of attributes of conditions and competencies.

Using a set of concepts, you can set a task, for example, in this case we need a set of conditions and competencies: C - a set of concepts defined by the task,

$$C = (c_1, c_2, c_3, c_4) \tag{2}$$

where c_1, c_2, c_3, c_4 are the selected concepts that fill the knowledge base of the ontological model of the knowledge and competency management system in the company [11].

For each concept, the weight value w_i where $0 \leq w_i \geq 1$ and $\sum_{i=1}^{n} w_i = 1$. which establishes the strength of the connection between the use case and the corresponding ontology concept. It is necessary to make a condition and build the parameters in the necessary sequence from the most important to the least important: $(w_1 = w_2) > w_3 > w_4$. The weight w_i is the more greater, the more important the presence of this parameter as the main one for solving the problem. To calculate the weights, we use the method of constructing the rating scale - the pair conditions method. Each of the parameters is compared in pairs and, based on the signs $=$, $<$ and $>$, the priority is set, and the value 1, 2 and 0, respectively. A matrix of pairwise comparisons is formed:

Table 1. Matrix of paired comparisons

	w_1	w_2	w_3	w_4	Sum	Weight
w_1	1	1	2	2	6	0,38
w_2	1	1	2	2	6	0,38
w_3	0	0	1	2	3	0,19
w_4	0	0	0	1	1	0,06

Accordingly, the weights are distributed as follows: $w_1 = w_2 = 0,38$; $w_3 = 0,19$; $w_4 = 0,06$. The weight of concepts can be determined in advance for

specific situations and used as a template. It is possible to determine the weight of the concepts and expand the search capabilities

It is possible to take both the conditions and the competencies themselves as concepts. The membership function μ_i for the competence is set by the values $\mu_i = 1$, $\mu_i = 0.5$ and $\mu_i = 0$, corresponding to the level of competency, where 0 is low, 0.5 is medium, 1 is high. Each of the conditions is also determined by three values. Accordingly, a large number of parameters can be made and it is possible to select more accurately the right employee in the weight distribution results, given the many conditions and combining several competencies.

After making the request, the function $P(c)$ calculates the maximum possible value, that is, the value μ_i^{max} and the weight w_i we need are selected. The value μ_i^{max} does not always indicate the level of competency, and therefore, cannot always be equal to one. Regarding conditions, it shows different semantic meanings. For example, for the condition "Time" it can be $\mu_i^{max} = 1$ – full-time, $\mu_i^{max} = 0.5$ – part-time, $\mu_i^{max} = 0$ – hourly payment. In addition, the request may not necessarily have excellent competency and a fairly average level, and therefore $\mu_i = 0.5$.

The maximum possible value of the function $P(c)_{max}$ or the query is calculated automatically after setting the necessary values of membership functions for each parameter. Further, when analyzing data for each employee, the function $P(c)$ calculates the value for each. After that, the value $P(c)$ for each k employees is compared with the value $P(c)_{max}$ obtained earlier and the absolute value of the difference is calculated:

$$l_k = P(c)_{max} - P(c)_k \tag{3}$$

where $-P(c)_k \leq l_k \geq P(c)_{max}$.

As a result of calculating the values l_k the following answers are defined:

1) the employee with the lowest value $l_k \rightarrow 0$ meets the requirements of the request.

2) for $l_k = P(c)_{max}$ query execution is impossible, that is, a suitable option was not found.

3) for $l_k < 0$ employee parameter values exceed the values specified in the request.

As a result of such comparison with the reference maximum value specified during the compilation of the request, it is also possible to determine how different each of the indicators $w_i\mu_i \in [0;1]$ for c_i parameter k employees, calculating the following absolute value of the difference:

$$w_i\mu_i^{max} - w_i\mu_i^k = s_i^k \tag{4}$$

where $-w_i\mu_i^k \leq s_i^k \geq w_i\mu_i^{max}$

For this comparison of individual parameters' values the following answers can be defined:

1) for $s_i^k \rightarrow 0$ the employee fully meets the requirements of the request for this parameter;

2) for $s_i^k = w_i\mu_i^{max}$ employee value is not enough;

3) for $s_i^k = -w_i\mu_i^k$ employee value exceeded

4   Results

In the course of the research, the verification and evaluation of the developed method was organized with the fulfillment of various requests on 6 users. The task of the search is as follows: to find a specialist with knowledge of SQL.

The following competencies were identified in the experiment (elements for analyzing the "Knowledge of SQL" competency): "Setting access rights", "Knowledge of the basic functions in SQL statements", "Triggers", "Designing the database structure", "Stored procedures", "Normalization/denormalization."

Table 2. Matrix of paired experiment comparisons

	w_1	w_2	w_3	w_4	w_5	w_6	Sum	Weight
w_1	1	1	1	1	1	1	6	0,17
w_2	1	1	1	1	1	1	6	0,17
w_3	1	1	1	1	1	1	6	0,17
w_4	1	1	1	1	1	1	6	0,17
w_5	1	1	1	1	1	1	6	0,17
w_6	1	1	1	1	1	1	6	0,17
Total							36	1,00

Table 3. Matrix of paired experiment comparisons

Name	Setting access rights	Knowledge of the basic functions in SQL statements	Triggers	Designing the database structure	Stored procedures	Normalization/ denormalization	$P(c)_k$	l_k
Anton	1	1	1	1	0	1	5	1
Alexey	1	1	0	1	0	1	4	2
Igor	1	1	0,5	0,5	0	0	3	3
Anna	1	1	1	0,5	0	1	4,5	1,5
Vasiliy	1	1	1	0,5	0,5	0,5	4,5	1,5
Egor	1	0,5	0,5	0	0,5	0	2,5	3,5

All these competencies are part of the more complex competency "Knowledge of SQL", and therefore determine the level of its knowledge. Each of the competencies-elements is important, as for the solution of the problem, "Setting access rights" and "Knowledge of the basic functions in SQL statements"

may be necessary. In our request, it is important that the employee possesses all the competencies-elements, then it is possible to assign him the more complex competence "Knowledge of SQL", determine the level of her knowledge and formulate recommendations for training.

Due to the fact that all competencies-elements are equally important, the matrix of paired comparisons for our request will look like on the Table 2.

To have the "Knowledge of SQL" competency, you need a high level for all competencies-elements, and therefore $P(c) = \sum\limits_{i=1}^{n} w_i \mu_i(c_i) = 6$

Table 3 presents the membership functions μ_i for competencies-elements corresponding to the level of competency, where 0 - low, 0.5 - medium, 1 - high.

As you can see, according to the results of the calculations, only user Anton meets the condition $l_k \to 0$ the rest of the participants can receive training recommendations.

5   Conclusions and recommendations

The presented competency management method was tested at the enterprises of the «SCAUT» group of companies and allowed to more than halve the errors in the selection and appointment of personnel for specific projects. It is applicable to competency monitoring, statistics collection and corporate training support. After implementing this method, it became possible to update the employee competency map, since one knowledge can come in different competencies, moreover, it became possible to collect separate data about employees working in certain projects and the competencies involved in them. If, for example, the number of people with this competency is less than 3, then you can accordingly engage in training employees or their retraining. If you want to get a certain position or role in the company, the employee can also check himself for the presence of the necessary level of competencies and additional conditions. In agreement with the management of the company, an employee can apply for training to obtain the relevant competencies. Thus, a bench for key positions will be formed. The method allows one to compare a potential employee for various parameters that are included in the request of the employer.

The results of the presented studies are largely correlated with the results of other scientists: «Overall, the contribution of the study has been to prove the viability of the General Systems theory when applied to the relationship between HRM practices and employee competence. This is evidenced from previous studies, such as GhebregiorgisKarsten (2007), Zingheim Schuster (2009) and Fey et al., (2000), which established positive and significant relationship between the various HRM practices and employee's hard and soft skill orientation of competence. The application of the theory illustrates the effectiveness of HRM practices in enhancing employee's competence at the firm level. This is crucial as firms' workforce could be designed and conditioned to support the firms' strategy and to boost the firms' performance» [7].

For many companies, a prerequisite for the workflow is to solve business problems with minimal time and resources. To do this, it is crucial to control the

availability of these resources, and in this case, competencies. Using a detailed comparison, it is less complicated to identify the lack of complex, but necessary competencies in the company. By means of this method, one can calculate the total number of employees with certain competencies and set a minimum value for them. In the future, conducting calculations anew as a result of the dismissal, training or retraining of employees, comparing with this value, it is possible to monitor the presence of competencies in the company, carry out effective management and maintain their required level.

References

1. Aleksandrov, D. V.,Zhebrun,N. N.: Ontological approach to the creation of a knowledge-based enterprise business process management syste. Bulletin of Tambov state technical University **5**, 26–31 (2007).
2. Barbosa, J. L. V., Kich, M. R., Barbosa, D. N. F., Klein, A. Z., Rigo, S. J.: DeCom: A model for context-aware competence management. Comput. Ind. (2015). https://doi.org/10.1016/j.compind.2015.03.012
3. Cakula, S., Salem, A. B. M.: E-learning developing using ontological engineering. WSEAS Trans. Inf. Sci. Appl. **10**, 14–25 (2013).
4. Harzallah, M., Vernadat, F. B.: Human resources competency management in enterprise engineering. IFAC Proc. Vol.(1999). https://doi.org/10.1016/s1474-6670(17)56028-0
5. Ley, T., Albert, D.: Identifying employee competencies in dynamic work domains: Methodological considerations and a case study. Journal of Universal Computer Science (2003). https://doi.org/10.3217/jucs-009-12-1500
6. Miranda, S., Orciuoli, F., Loia, V., Sampson, D.: An ontology-based model for competence management. Data Knowl. Eng. (2017). https://doi.org/10.1016/j.datak.2016.12.001
7. Mohammed, Y.A. Alsabbah, HazrilIzwar Ibrahim: HRM practices and employee competence: a general system perspective. International Journal of Business, Economics and Law, vol. 4, Issue 1 (2014). ISSN 2289-1552
8. Munir, K., Sheraz Anjum, M.: The use of ontologies for effective knowledge modelling and information retrieval. Appl. Comput. Informatics (2017). https://doi.org/10.1016/j.aci.2017.07.003
9. Nikitina, L., Shikov, P., Shikov, Y., Bakanova, A., Shikov, A.: Recommended system of personalized corporate e-learning based on ontologies. in MATEC Web of Conferences (2018). https://doi.org/10.1051/matecconf/201819305074
10. Okulov S. A., Chunaev A.V., Shikov A. N. Formation of corporate training management system by means of information technologies. Achievements of modern science vol.1, **4**, 170-174 (2017).
11. Pérez-Rodríguez, R., Anido-Rifón, L., Gómez-Carballa, M., Mouriño-García, M.: Architecture of a concept-based information retrieval system for educational resources. Sci. Comput. Program. (2016). https://doi.org/10.1016/j.scico.2016.05.005
12. Torkkeli, M.,Tuominen, M.: The contribution of technology selection to core competencies. Int. J. Prod. Econ. (2002). https://doi.org/10.1016/S0925-5273(01)00227-4