Measuring Professional Competencies of Virtual Teams: Fuzzy-logic Based Model

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Abstract - ***In this paper we attempted to build on and innovate the model set by the scientist Hyeongon [5] in order to simplify it and make it more universally applicable. This is the best quality of our research. Namely, its application exceeds the framework of virtual team competence defining. It can be implemented by prospective project financiers, research institutes, ministries and others. In addition to formulating the original model, the authors propose that a database of experts should be formed on the basis of the keywords from their publications.***

Index Terms: ***Virtual team, Personal competency, Collaboration competency, Virtual university, Fuzzy–logic based model***

1. INTRODUCTION

The introduction of IT into an organization can greatly change the day-to-day tasks done by the workers in the organization. Organizational changes that occur under the influence of the digital age can be defined as the difference in form, quality or state over time in an organizational entity [12]. Therefore, different workers must learn new skills and new ways of communication do the work successfully in virtual teams. The idea of creating virtual teams is due to the advances in information and communication technologies. The team is called virtual because collaboration does not take place through real interaction, but in a virtual environment and possibly its members have never interacted with each other live "face to face", but only indirectly, through technical means - this is the other aspect of the term "virtuality“ [7].

In his work [10] maintains that the knowledge the virtual teams use is the knowledge owned by the team members. Using the knowledge of a virtual team increases the number of individuals accountable in the knowledge sharing process, thus creating a broad organizational network. In other words, virtual organizations can improve their internal knowledge sharing through forming virtual teams whose explicit task is to share knowledge and persuade other employees to follow their example. It is important to note that the formal knowledge of the whole team ensures organizational strength and legitimity both on the team level and on the individual level.

When assembling a team, special attention is paid to its structure. The structure itself should be such that the skills, competencies and character traits of team members are complementary. Teams with the same or similar profiles of experts have not proved to be efficient in practice. Besides, practice imposes that, apart from skill and work experience, the criteria for team member selection should include the member character traits. The traits such as vigour, persistance, perseverence, tactfulness, cooperability, loyalty to firm are the preconditions of the team success, in as much as it is the skills and the expertise of the team members. Successful virtual team building is challenging because teams are frequently composed for short periods of time and are created to tackle specific tasks.

2. THEORETICAL BACKGROUND

The term ‘‘competency’’ is often used as an umbrella term to cover almost anything that might directly or indirectly effect job performance within a specific work environment [3]. Competency is the capability of an individual verified by a written document and stating the fact that this individual is capable of doing a certain job. It is important to point out that, in the course of his/her education, the individual develops his/her competence in accordance with the standards set for that job [8]. Competencies specify the "how" of performing job tasks, or what the person needs to do the job successfully [14]. This can be applied to individual dispositions or to the distribution of such dispositions within a social group or an institution [11].

A large number of competencies can be grouped into two classes:

- competencies that can be successfully implemented in a large number of different tasks (general competencies)

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- knowledge, skills or strategies adequate to the organization that is specific and requires that one adapts in a specific manner.

Researcher Aken [1] created a special methodology on the basis of which the highly educated personnel are expected to develop at least five areas of general competencies:

1. Professional expertise: the highly educated are expected to be experts in their professional areas;

2. Functional flexibility: it is understood that highly educated personnel have to be able to respond to new challenges and promptly capture new knowledge;

3. Innovation and knowledge management: apart from being able to perform their tasks effectively, the highly educated are expected to create an environment in which innovation management will be knowledge-based;

4. Human resource mobilization: the highly educated are expected to mobilize all available human resources and guide them in a desired direction;

5. International orientation: highly educated persons are expected to be strongly inter-oriented, given the globalization processes.

3. RESEARCH METHODOLOGY

This research, unlike most, is different in terms of methodology. It focuses on individual competencies, whereas the literature dealing with more social networks. The reason for this is the fact that it is generally neglected personal competence, which is of great importance in the selection and formation of virtual teams. Accordingly, in defining formula to calculate the personal competencies, we have taken into account various factors that are important for its measurement.

According to Hyeongon [6], there are three basic components in the knowledge management principle and these are: 1. Know what is necessary; 2. Know how to apply that and 3. Know who is capable of applying, i.e., who is closely acquainted with the problem. The proposed model offers a ranking list of most competent persons. Since the project manager has to display the traits of a leader and the ability to recruit competent collaborators in forming a virtual team, it is necessary that he/she should establish their competencies.

On the basis of the above mentioned knowledge management principles, the competency of the virtual team members is mathematically established eq. (1):

Knowledge Competence (KC) = Personal Competence (PC) + Collaboration Competency (CC) (1)

where KC is the aggregate competency of each individual team member that a project requires in terms of keywords; PC is the personal competence defined on the basis of already published works; CC is the aggregate collaboration coefficient of each individual member as result of authorship in publications.

Competency-based assessment is a process that determines whether a person meets the standards of performance required by a job. It is a new and unfamiliar technique to many practitioners arousing numerous queries, interest, and even objections [4]. Competency assessment is an ongoing process of continually building knowledge and skills (Figure 1).

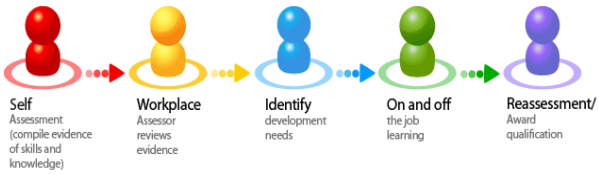

Figure 1 A typical competency assessment process: Source: http://www.cognology.com.au/cbawhatis.htm

Competency-based assessment directly measures skills and abilities specially relating to the particular job for which the assessment is conducted [9]. It is important to balance these skills and elements of the job with personal attributes so that allowance is made for the individual to use their discretion and creativity in achievement of outcome [4].

3.1 The Method of Assessing the Employee Personal Competency at a Virtual University

In this research we used the fuzzy system of deduction to assess personal competence coefficient. Personal competence and knowledge of the staff cannot be expressed as exact numerical values, as this implies ambiguity and complexity. The fuzzy logic is a concept that can be used to bridge the gap between human reasoning and computer logic [15] [13]

Personal competence is defined on the basis of individual employees' published works having in mind the congruity of keywords in publications and the keywords on the projects in the last five years. As projects are rather complex in structure, a larger number of keywords n is requested. By forming the combinations essential for words of minimum second order, $C = \binom{n}{r}$ where C is the number of combinations, r is the order number, n is the total number of keywords,

the search is performed. Practice has shown that the reference search by the title is not efficient since there is a probability that the title does not contain the keywords searched for. The search through the whole text of the publication does not yield the desired results either. Hence we decided upon the search by the keywords from the references that researchers entered into the database of the virtual university.

In case of unique references that satisfy a certain criterion the difference in the year of publication and the number of authors are entered individually into the Fuzzify logic. The obtained Defuzzify values range in the interval between 0 and 1. (Fig. 2)

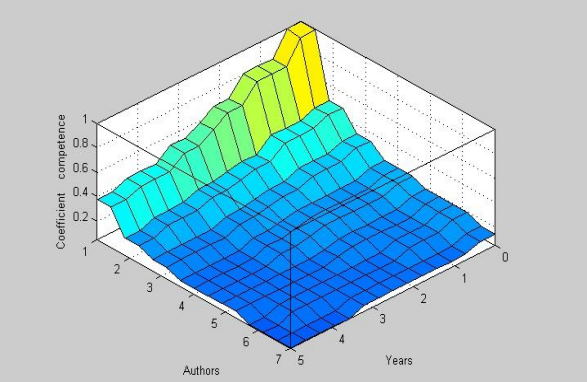

Figure 2 Competence Coefficient *Source: Authors*

Figure 1 shows that the highest coefficient is obtained in case the publication appears during the year of search and is the work of one individual author.

The graph (Fig. 2) shows that in case the value of the author axis equals one, the 2D diagram is obtained (Fig. 3).

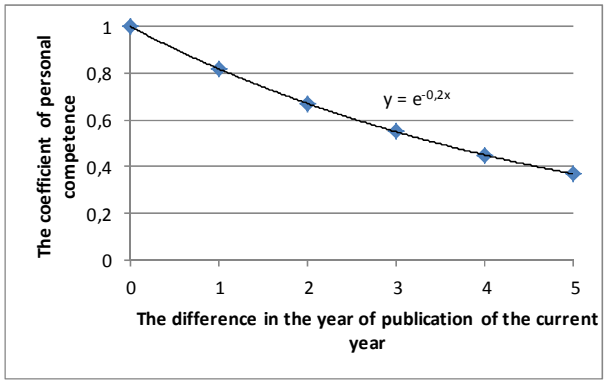

Figure 3 Personal Competence Coefficient depending on the year of publication (author axis = 1)

All the values of nodes in Figure 2 show the trend of the equation $Y = e^{-0,2x}$, which would, upon reducing it to the fraction in the exponent, result in $Y = e^{-\frac{x}{5}}$. Here the denominator in the exponent is the time interval *D*, whereas the value *x* can be written as a difference between the year of publication *n* and the current year *m*. Now the formula takes a modified form $Y = e^{-\frac{(n-m)}{D}}$.

The graph (Fig. 1) shows that in case the year axis equals one, the 2D diagram is obtained (Fig. 3). All the values of nodes in Figure 3 show the trend of the equation $Y = n^{-1}$ which is a reciprocity between the number of authors of the publication.

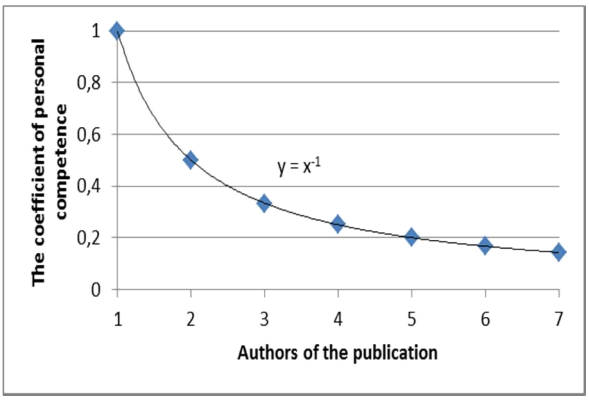

Figure 4 Personal Competence Coefficient depending on the number of authors (year axis = 1)

Types of publications differ (Table 1) and they may be of greater or lesser significance for the different purposes of forming virtual teams.

The significance will be valued by the project financier, following the principle of adding the weight factor for each type of publication he finds relevant. In case of scientific research projects, of greater significance are such publications as a paper published in a journal of top international importance and a paper in an international journal or a monograph of international importance, while virtual companies may find patents or project reports more important. The values of weight ratios V_k may range from 1 to 10 for important publications and the value 0 for those not important for the project sponsor.

Table 1 Types of publications

Num.	Type of publication	Values
1	International importance monograph	5
2	Paper in the Proceedings of international character	10
3	Editing theme proceedings	2
...	.....	

Calculating personal competence for each person whose references satisfy certain keywords is defined in formula (2):

$$PC_i = \sum_{j=1}^{M} \sum_{k=1}^{N} PC_{i,j,k} * V_k \quad (2)$$

where PC_i is the personal competence coefficient of *i* member, *j* is the combination of keywords for *j = 1... M, k* is the type of publication for this keyword for *k = 1...N, V_k* is the weight ratio for an individual relevant type of publication.

3.2 Measuring the collaboration competency

When the references of employees at the virtual university, of authors and co-authors of papers are entered, a network of collaborators is created. The nodes in this network represent individual collaborators and their interrelation is presented by the papers they collaborated on. Such a network is one to which a social network analysis can be applied, and this analysis includes several major indicators of the quality of the network and its individual nodes (in this case, collaborators). The main communication SNA measures among the members of a virtual team are the density of the global network as well as the density of each group, whereas coordination measures are the degree centrality, closeness centrality and betweenness centrality. The interpretation of these measures is as follows: degree centrality - how many people this person can reach directly; closeness centrality - how fast this person can reach everyone in the network and betweenness centrality - how likely this person is to be the most direct route between two people in the network. Communication measures indicate the intensity of overall team communication, so they are not appropriate as criteria for selecting a project manager; the coordination measures, however, are useful for selecting a project manager. High coordination measure means high liability to have access to any information or knowledge available in a network of team members, so if we select a competent project manager in favor of high values of degree centrality and closeness centrality, it is possible to improve the project performance.[2]

$KC_i=PC_i+(dc_i+bc_i+cc_i)$ (3)

dc_i – *degree centrality*$_i$
bc_i – *betweenness centrality*$_i$
cc_i – *closeness centrality*$_i$

The person that gets the maximum weighted average of knowledge competence score, degree centrality, and closeness centrality should be appointed project manager, eq.(4)

$Max\ \{PC_i + (dc_i+bc_i+cc_i)\}$ (4)

The knowledge competence of a whole virtual team would be equal to the sum of all the members that satisfy the previously listed criteria: eq. (5)

$$KC = \sum_{i=1}^{P} KC_i \quad (5)$$

i = team member for *i = 1...P*

On the basis of the previous analysis of the team members and the team leader selection a prototype was designed using the programming language VC#, SQL Server 2008 OLAP, XFuzzy 3.0, as well as NodeXL. The XFuzzy 3.0 modelling tool for fuzzy model is used to model a fuzzy system of deduction for the assessment of personal competence coefficient and includes a possibility to generate a code to be used as an external function in the SQL Server 2008. The entire computing of personal competence is performed within a server and the final result is presented in OLAP. The VC# was used to enter keywords and weight ratios of individual publications, while NodeXL was used to compute the component of collaboration competency. To test the model, references of 23 authors and 143 publications of various types were entered.

4. AN EXAMPLE OF HOW THE METHOD MAY BE APPLIED

This example contains the definitions of keywords that come out of the definition of the project subject for which the virtual team members are obligated to be competent. (Table 2)

Table 2 Project keywords

Project keywords
New economy, economic lessons integration

The search of publications starts upon creating a number of keyword combinations, and the result has to satisfy the AND criterion.

Integrated search results are presented in Table 3 (Appendix 1)

The year of publication and the number of authors are entered into the fuzzyfy and the fuzzy model output values are obtained. Weight values of individual references give the sponsors project depending on what is most relevant to them, which may not be consistent evaluation of the scientific community. For selected keywords (Table 2) the calculated values knowledge competence, of individual employees is shown in (Table 4).

Table 4 Knowledge Competence

Personal knowledge		Collaboration competency		
Employee	PK_i	dc_i	bc_i	cc_i
Empl. 1	22.38093	12	52	0.083
Empl. 2	4.28571	1	0	0.043
Empl. 3	4.28571	1	0	0.043
Empl. 4	2.85714	6	3	0.056
Empl. 5	1.90476	3	0	0.048
Empl. 6	1.90476	3	0	0.048
Empl. 7	1.90476	2	0	0.045
Empl. 9	1.42857	2	0	0.045
Empl. 10	1.42857	2	0	0.045
Empl. 11	.95238	4	0	0.050
Empl. 12	.95238	4	0	0.050
Empl. 13	.95238	4	0	0.050
Empl. 19	1.90476	2	0	0.045

Table 4 shows that the employee with the maximum competence is Employee 1 with a total score of KC_1=86.46393. When all the employees from Table 4 are admitted into a virtual team, the competency of the virtual team is obtained KC= 148.79381.

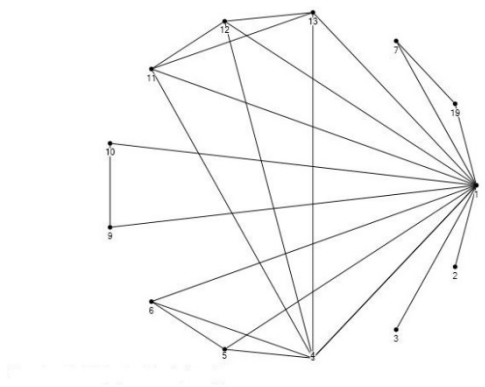

Figure 5. The network diagram of employees

5. CONCLUSION

In this article a procedure for evaluating the competence of the leader of the project team and its members, who are employed on virtuel University is proposed. Candidate knowledge assessment (within a broader evaluation of their independent work concerning personal competence) as well as that of time relevance of publications in a quantitative domain was performed using the fuzzy model. These quantitative ratings helped us assess candidates for projects in a more unbiased manner. The novelty is also that the project financiers themselves can value the types of publications according to the criterion they favour. The rating of collaboration competency within the social network helps obtain a more objective assessment in selecting prospective team members with a high degree of knowledge and cooperability. The employee with maximum knowledge required for the project, one that can ensure a high degree of collaboration through a social network is appointed project manager. On the basis of these results a competent virtual team can be assembled, capable of effectively solving the tasks set before them. We expect that our methodology will be implemented in practice. However, it should be also a good basis for further improvements in this area.

REFERENCES

[1] Aken, J. v. H. L. &. P. G., 1998. Virtual Organization: a special mode of strong interorganizational cooperation. In: R. I. C. J. N. D. M.A., ed. Managing Strategically in an Interconnected World. s.l.:Chicester: John Wiley & Sons.

[2] Carla Sofia Pereira, A. n. L. S., 2007. Improving the quality of collaboration requirements for information management through social networks analysis. International Journal of Information Management, Volume 27, p. 86–103.

[3] Fischer, H. & Maritz, D. (1994). Competence: E⁄cient way of increasing people potential.HRM.10(9), 22-30.

[4] Hager, P. & Gonczi, A. (1994). General issues about assessment of competence.Assessment &Evaluation inHigher Education,19(1).

[5] Hyeongon Wi, S. O. J. M. M. J., 2009. A team formation model based on knowledge and collaboration. Expert Systems with Applications, Volume 36, p. 9121–9134.

[6] Hyeongon Wi, S. O. M. J., 2011. Virtual organization for open innovation: Semantic web based inter-organizational team formation. Expert System with Applications, Volume 38, pp. 8466-8476.

[7] Krum ,K. & Radovic-Markovic,M.(2013), Globalization and organizational change: major challenges in multi-cultural virtual project teams, chapter in the book: ENTREPRENEURSHIP, FINANCE AND EDUCATION IN THE DIGITAL AGE, LAP LAMBERT Academic Publishing ,Germany.

[8] Marković, M. R., 2011. Obrazovni sistem i potrebe privrede u Srbiji. In: J. Zubović, ed. Aktivne mere na tržištu rada i pitanja zaposlenosti. Belgrade: Institut ekonomskih nauka, pp. 27-43.

[9] Morrall, L. (1997).Competency-based interviewing and selection methods within the new Labour Relations Act.

[10] Olli-Pekka Kauppila, R. R. a. A. J., 2011. Knowledge sharing through virtual teams across borders and boundaries. Management Learning, 42(4), p. 395–418.

[11] Potgieter ,T. & De Merwe,V. (2002). Assessment in the workplace:A competency-based approach, SA Journal of Industrial Psychology,2002,28(1),60-66

[12] Radovic Markovic, Mirjana and Salamzadeh, Aidin and Markovic, Dusan and Grozdanic, Radmila and Vucekovic, Milos (2012), E-Learning in Business and Entrepreneurship: Evidence from Serbia, Iran, and India (December 1, 2012). 1st Annual International Conference on Employment, Education and Entrepreneurship, 2012. Available at SSRN: http://ssrn.com/abstract=2203718

[13] Ross, T. J., 2010. Fazzy Logic With Engineering Applications. Third Edition ed. s.l.:John Wiley & Sons, Ltd.

[14] Shippman, J. S., Ash, R. A., Carr, L., Hesketh, B., Pearlman, K., Battista, M., Eyde, L. D., Kehoe., J., Prien, E. P., & Sanchez, J. I. (2000). The practice of competency modeling. Personnel Psychology, 53, 703-740.

[15] Schmidt, S., Steele, R., Dillon, T. & Chang, C., 2007. Fuzzy trust evaluation and credibility development in multi-agent systems. Applied Soft Computing, Volume 7, p. 492–505.

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APPENDIX 1

Table 3 Search results by keywords

Type of publication	Year of publication	Publication	Keywords	Authors
International book	2011	1	Management, Management dynamics, Managerial functions, Corporate policy, New economy, Management	Employee 1 Employee 2
The paper in the Proceedings of an international character	2011	2	Economic integration, European Union – Polish economic integration	Employee 1 Employee 3
Editing thematic collections	2011	7	European Union, Serbia, New member states, Economic lessons	Employee 1 Employee 4 Employee 5 Employee 6
International book	2007	15	Entrepreneurs, New economy, E-business, E-entrepreneurs, Globalisation	Employee 1
National importance monograph	2007	19	New economy, Leadership, Managers and leaders in new economy	Employee 1 Employee 9 Employee10
International journal article	2007	28	New Economy, Small business organizations	Employee 1
Editing the international monographs	2009	29	New economy	Employee 1 Employee 4 Employee 11 Employee 12 Employee 13
Monographic study	2009	34	New economy, Women's Entrepreneurship, Enterpreneurship in Serbia	Employee 1 Employee 7 Employee 19