Future Academy®
Offering excellence in Social and Behavioural Sciences

The European Proceedings of
Social & Behavioural Sciences
EpSBS

eISSN: 2357-1330

WELLSO 2015 - II International Scientific Symposium on Lifelong Wellbeing in the World

Complicated Adaptive Systems as a Way to Improve Higher Education

Olga Korneva[a]*,Vladimir Kazakov[b], Anna Ustuizhanina[c],Oksana Efremova[d]*

* Corresponding author: Olga Korneva, okorneva-st@rambler.ru, +79138206715

[a,c,d] *National Research Tomsk Polytechnic University, 30 Lenin Ave., Tomsk, Russia.*
[b] *National Research Tomsk State University, 36 Lenin Ave., Tomsk, Russia.*

Abstract

http://dx.doi.org/10.15405/epsbs.2016.02.52

The aspiration to constant economic wellbeing and intensive transformation of the scientific world detects a problem of adaptation in high professional education (HPE). The HPE system built in the socio-economic structure reacts with a delay to changes in the environment. In the article we claim that HPE systems have features of bio-systems: self-preservation and adequate response to external stimuli. It is supposed that this delay can be overcome if we insert into the system the elements which can improve its adaptability. As the quantitative evaluation of the system gives no grounds to the model construction, our study offers a new concept of high professional education model building. To make a diagnostics of the HPE system and to create a model of HPE adaptation to the environmental challenges we use the method of fuzzy logics, comprising a base of rules and membership functions. The proposed algorithm of fuzzy output is based on the expert assessment data of the Russian Association of Engineering Universities received during the accreditation of engineering specialties in 10 universities of Russia.

Keywords: Keywords should be separated by a semi-colon ; Times New Roman 8

1. Introduction

In the context of the global confrontation and competence of all the world market participants the problem of the economic safety principles consists in finding the optimal ratio between the strategic stability and economic growth. It is assumed that the latter is achieved by the national innovative system development and by the investment in human capital, science, technology and education.

The development trajectory of the national economy and its competitive advantages are based on the material, infrastructure and financial resources. An important role is played by human resources, government, competitiveness and goal setting of Russian companies. In today's economy, the quality of

http://dx.doi.org/10.15405/epsbs.2016.02.52
eISSN: 2357-1330 / Corresponding Author: Olga Korneva, Email: okorneva-st@rambler.ru
Selection and peer-review under responsibility of the Organizing Committee of the conference

economic growth is provided due to investments into intangible economic assets: research and development, innovative activity increase, education and advanced training of the economically active population. Thus, the investigation in the field of high educational system is of great importance nowadays, in our time of interdisciplinary scientific discoveries and problems of human activity connected to the technical progress, etc.

The literature review on the topic of adaptation in the sphere of education shows that this problem is covered with two positions:

- The adaptation of students to the new knowledge has been discussed in the scientific works of D. Essam, T. Gedeon, T. - C. Hsieh, T.-I. Wang, C.-Y. Su. , M.-C Lee, W. Wilke, I. Vollrath, K.-D. Althoff, R. Bergmann, S. Craw, N. Wiratunga, R.C. Rowe, A. Cordier, B. Fuchs, A. Mille.
- The creation of adaptive Web-applications for specific educational activities is developed in the works of Alejandro Peña-Ayala,K. Mehrotra, C. K. Mohan, S. Ranka, Chia-Feng Juang, Buckley J.J. Chin-Teng Lin, E. Eslami, J.S.R. Jang, C.T. Sun, E. Mizutani .

There is a series of studies devoted to the adaptive management in the fields not connected to the educational system: Gelu-OvidiuTirian, Ioan Filip, and Gabriela Proştean, D. Moriarty, R. Miikulainen, Igel Christian, In R. Sarker, R. Reynolds, H. Abbass, K. C. Tan, B. McKay. But the problem of adaptation of the educational system itself has never been deeply investigated.

2. The innovation resistance

Complicated adaptive systems (CAS) are a specific case of complicated systems (Cristea, D. 2010). Their complexity is determined by their diversity and composition. HPE is considered to be one of the CAS (as it is a set of interrelated elements capable of adaptation to the environment) (Tirian G.O 2014). The creation of model for HPE as a CAS involves the adaptation of this system to the conditions of constant transformation of modern scientific world and its influence on the advancing processes in economics. The system adaptation implies an adjustment to real external conditions when the system changes its structure and chooses new variants of behavior under the influence of environmental factors according to the new emerging system goals (Volkova, Kozlov 2004). According to T.Yu.Tyukin and V.A. Terekhov, adaptation and self-organization are similar by their principles and results (Tyukin, Terekhov 2008).

The principal task of CAS building is the selection of necessary information and choice of strategy in the conditions where non-standard algorithms should be used. Today such systems are widely used to study the social-economic processes and to describe the fuzzy academic sphere which arises around these systems (Forrester 1968). The «normal» evolution of CAS involves the ability to self-organize, which is manifested in the self-consistent system operation due to its inner connections with the environment. Here two stages can be identified: the adaptation and the selection. Having a mechanism of constant adaptability to changing conditions, the system is continuously improved basing on the past experience. In our study of the adaptation processes we start from the assumption that structure and function are interrelated: a system can transform its structure in order to perform given functions in conditions of changing environment. The adaptation of the system to the changing conditions is due to

the appearance of elements possessing the properties necessary for the system functioning. According to the concept of structural stability, such elements should be redundant (Tom, P., 2002).

3. Model indicating the barriers to innovations

The HPE system modeling is based on the idea of self-preservation and adequate respond to external stimuli. It is similar to bio-systems and includes:

- the systematic analogy of building;
- the use of information protection mechanisms: hierarchy of protection levels, preservation of genetic information on the lower hierarchy levels, providing communication with the external environment on the upper hierarchy levels, safety due to the adaptability and acquisition of life experience, choice of behavior in a constantly changing environment;
- the possibility to inherit the accumulated experience of such systems in the form of data fields, clustering the external stimuli, adaptation of the data field, analysis of the information from other systems.

The possibility to «teach the system» is its most important quality, which helps it to adapt to the environment (Forrester, J.W., 1968). During the adaptation process the redundancy of information is reduced, it is classified and the primary tasks of transformation are determined. The problem of unbalanced data sets classification is solved by fuzzy logic algorithms which are implemented for large data volumes (Tom, P., 2002).

The method allows to distribute fuzzy logic computing operations to eliminate the data imbalance. The obtained results show that the proposed model can solve these problems and give competitive results taking into account both qualitative and temporal variation of a characteristic. Let us assume that the HPE system is based on four principles:

- systematicity;
- fundamentality;
- advanced education as a response to the external stimuli;
- complementary efficiency and diversification.

Each principle corresponds to six vector outputs (assessment parameters). For the systematicity principle analysis they are:

1. availability of the profile preparatory system,
2. connection with primary and secondary education,
3. material resources,
4. availability and level of international relations,
5. classroom fund quality,
6. use of Management by Objectives methods.

The fundamentality principle is analyzed through the following criteria:

1. availability to study the basic sciences (physics, mathematics, chemistry etc.),
2. availability of training courses, developing mental abilities (systematic, abstract and analog thinking),

http://dx.doi.org/10.15405/epsbs.2016.02.52
eISSN: 2357-1330 / Corresponding Author: Olga Korneva, Email: okorneva-st@rambler.ru
Selection and peer-review under responsibility of the Organizing Committee of the conference

3. availability of tools allowing to use basic knowledge to solve tasks in the future professional activity (for example, whether the institution has a supercomputer),

4. use of interactive learning elements (which enables to develop the ability to analyze and synthesize, to focus on solving theoretical and applied problems in various fields and act appropriately in different conditions),

5. participation of academics in the educational process,

6. participation of students in the scientific research.

The principle of advanced education and relation to the external stimuli corresponds to:

1. use of command training methods in the education and project activities,

2. use of practice-oriented educational technologies, problem-based and project-organized learning,

3. availability of educational programs allowing the future specialists to acquire standard and specific competences which will provide them with a high level of relevance in the professional environment,

4. availability of elite technical education in engineering universities, allowing to select the most talented and motivated students and train them in the advanced education program for their future research and project activities,

5. presence of a permanent professional development and retraining system in all spheres of training in the field of engineering and technology,

6. presence of special analytical centers (on the federal, regional and institutional levels) performing a constant analysis of external challenges to the system of training and working out recommendations to provide the adaptation of HPE system to the changing conditions.

The principle of complementary efficiency and diversification is assessed by:

1. availability of interdisciplinary programs and training courses,

2. availability of an Entrepreneurship Center providing conditions for the development of business and creative initiatives of citizens working in various fields of engineering and technology,

3. presence of the Academic Mobility Center providing the internationalization of the high professional education,

4. presence of a problem analysis and problem situations center in the field of engineering and technology which creates and maintains a technological problems database,

5. availability of programs accredited by the international and domestic systems of engineering education programs professional accreditation,

6. availability of educational programs based on the best designing experience of the leading Russian and international universities (with the participation of leading international experts).

4. The systematicity principle analysis

In this article we apply our model on the example on the systematicity principle analysis. We divide the structure into diagnostic systems, with a limit in each of them. Our approach assumes that the analyzing system will include two levels for each principle (Fig. 1). The first one checks the presence of the systematicityprinciple, the second one determines the degree of discrepancy. Thus, when

building this subsystem, the expert divides the data selection into two classes: class (-1) represents the high educational institutions which do not correspond to the systematicity principle, class (1) includes the corresponding ones. The importance of these features is confirmed by statistical criteria. The structures of the other three principles are analyzed in the same way.

The subsystem includes the decision block which approximates the available data to regularities by means of a cascade neuro-fuzzy network. Then the response output in the range of (-1) to (1) is displayed. A value greater than0 indicates that the analyzed university has the corresponding parameters at the development stage (contracts are made, projects are developed, etc.), so the university corresponds to the systematicity principle. A value less then0 shows the discrepancy to the principle.

The network has a cascade converging tree structure with vector inputs. In the course of "training" the apriority unknown network parameters adjust themselves.

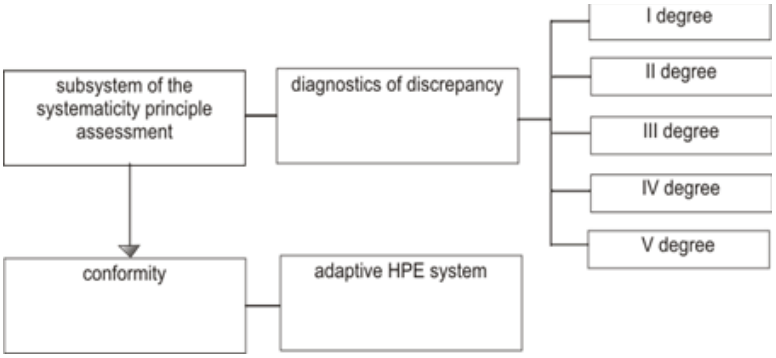

Fig. 1. Structure of the systematicity principle analysis

Building the cascade neuro-fuzzy network is carried out according to the formula

$$y = y(n) = sign[G(u) - N] + N,$$

$$N = \frac{y_{\min} - y_{\max}}{2},$$

wherey - is the result of analysis, G(u) is a complementary function, for which the mutually opposite fuzzy statements are formed, N is the average output value.

The structure includes three layers. A vector (one of the six analyzed features of the systematicity principle) comes to the input of the first layer. The results of the correlation are shown in Table 1.

Table 1. Values of the input parameters correlation for the systematicity principle assessment

№	x_1	x_2	x_3	x_4	x_5	x_6
x_1	1					
x_2	-0.14	1				
x_3	0.38	-0.27	1			
x_4	0.56	0.38	0.02	1		
x_5	-0.20	0.14	-0.25	-0.24	1	
x_6	-0.19	0.13	0.38	0.19	-0.14	1

Here x_1 is the availability of the profile preparatory system,x_2 - connection with primary and secondary education, x_3 -material resources, x_4 - availability and level of international relations, x_5, - classroom fund quality, x_6 - use of Management by Objectives methods.

http://dx.doi.org/10.15405/epsbs.2016.02.52
eISSN: 2357-1330 / Corresponding Author: Olga Korneva, Email: okorneva-st@rambler.ru
Selection and peer-review under responsibility of the Organizing Committee of the conference

The structure of a node with two inputs and one output is described in accordance with the rules given in Table 2.

Table 2. First layer of using the fuzzy database for the systematicity analysis modeling (2 inputs, 1 output)

#	x_1	x_2	x_3	x_4	y
1	high	high	high	high	The system exists
2	average	average	average	average	No system
3	high	low	high	low	The system exists
4	average	high	average	high	The system exists
5	high	average	high	average	The system exists
6	average	low	average	low	No system

The structure of a node with four inputs and one output is given in Table 3.

Table 3. Second layer (4 inputs, 1 output)

#	x_1	x_2	x_3	x_4	y
1	high	high	high	high	The system exists
2	average	average	average	average	No system
3	high	low	high	low	The system exists
4	low	low	low	low	No system
5	low	-	low	low	No system
6	high	-	high	high	The system exists
7	-	low	low	low	No system
8	-	high	high	high	The system exists
9	high	high	low	high	The system exists

Connecting the outputs of the first layer according to the rules (Table 4) we get the groups for the second layer of the expert system ($y_{1,1}$, $y_{1,2}$, $y_{2,1}$).

Table 4. Third layer: data summary

#	$y_{1,1}$	$y_{1,2}$	$y_{2,1}$
1	The system exists	The system exists	The system exists
2	No system	No system	No system
3	The system exists	No system	The system exists
4	No system	The system exists	The system exists

Analyzing the quality of this system functioning and taking into account possible errors of the expert assessment concerning “true” values, we come to the conclusion that the possible error is 1.6 % under expert evaluation leading engineering and traditional universities with a history of over 80 years.

The creation of the HPE system adaptation model serves as a basis for methodology of the system self-tuning process and its adaptation to the conditions of global economic transformations. It includes the enrichment of its contents as well as important structural changes, where the structure implies a set of relations between the elements. Thus, the influence of external conditions constantly leads to the HPE evolution, and then the HPE itself transforms the environment. The mechanism of these two spheres interaction (with all the necessary institutional superstructures and feedback) is built. This mechanism provides, from one hand, the transfer of knowledge, its distribution and transformation into pre-competitive technologies for business environment. From the other hand, it provides the orientation of the research sphere at the response to any emerging innovative requirements of production development.

5. Conclusion

The adaptation research and education centers, due to their advance principles, acquire federal and world significance, form strategic initiatives, provide a high scientific, technical, intellectual, human and social-economic potential of regions and of the country as a whole. It increases the contribution of the regions to the country's GDP growth and in the long term the whole adaptation system will allow the state to become a developer for the neighboring territories.

Acknowledgements

This work was performed by the author in collaboration with Tomsk Polytechnic University within the project in Evaluation and enhancement of social, economic and emotional wellbeing of older adults under the Agreement No.14.Z50.31.0029

References

Association for Engineering Education of Russia. Issue 12, 2013. Available online: July 5, 2014. http://aeer.ru/en/magazine12.htm

López de Mántaras, R., McSherry, D., Bridge, D., Leake, D., Smyth, B., Craw, S., Faltings, B. Maher, M.L., Cox, M.T., Forbus, K., Keane, M., Aamodt, A., Watson, I. (2005) Retrieval, Reuse, Revision, and Retention in Case-based Reasoning. In: *Knowledge Engineering Review*, 20 (3), 215–240.

Tekol, Y., Acan, A., (2003) Ants Can Play Prisoner's Dilemma. In: Sarker, R., Reynolds, R., Abbass, H., Tan, K. C., McKay, B., Essam, D., Gedeon, T. (eds.) Proceedings of the 2003 IEEE *Congress on Evolutionary Computation (CEC2003). Canberra, Australia. IEEE Press*, pp. 1348-1354,

Acan, A., Unveren, A., Tekol, Y. (2003) Evolutionary Estimation of Assignment–Ordering Function for CSP–Modeled Combinatorial Optimization. In: Sarker, R., Reynolds, R., Abbass, H., Tan, K. C., McKay, B., Essam, D., Gedeon, T. (eds.) Proceedings of the 2003 IEEE Congress on Evolutionary Computation (CEC2003*). Canberra, Australia. IEEE Press*, pp. 256- 263.

Acan, A., Altincay, H., Tekol, Y., Unveren, A. (2003) A Genetic Algorithm with Multiple Crossover Operators for Optimal Frequency Assignment Problem. In: Sarker, R., Reynolds, R., Abbass, H., Tan, K. C., McKay, B., Essam, D., Gedeon, T. (eds.) Proceedings of the 2003 IEEE *Congress on Evolutionary Computation (CEC2003). Canberra, Australia. IEEE Press*, pp. 560-565.

Hsieh, T.C., Wang, T.I., Su, C.Y., Lee, M.C. (2012) A Fuzzy Logic-based Personalized Learning System for Supporting Adaptive English Learning. In: *Educational Technology & Society*, 15 (1), 273–288.

Peña-Ayala, Alejandro (2013) Intelligent and Adaptive Educational-Learning Systems: Achievements and Trends. Berlin ; New York : Springer, p.524

Buckley, J.J., Eslami, E. (2003) Uncertain probabilities I:the discrete case. Soft Computing - A Fusion of Foundations, *Methodologies and Applications* 7(8), 500-505

Moriarty, D.E., Miikkulainen, R. (1994) Improving Game-tree Search with Evolutionary Neural Networks. In: Proc. 1st IEEE Conf. Evol. Comput., IEEE World Congr. Comput. Intell., pp. 496–501.

Igel, C. (2003) A Note on Generalization Loss When Evolving Adaptive Pattern Recognition Systems. *IEEE Transactions on Evolutionary Computation*, 17 (3), pp. 345-352.

Hsieh, T.C., Wang, T.I., Su, C.Y., Lee, M.C.: A Fuzzy Logic-based Personalized Learning System for Supporting Adaptive English Learning. In: *Educational Technology & Society*, 2012, 15 (1), 273–288.

Cristea, D., Prostean, O., Muschalik, T.,Tirian, G.O. (2010) Contribution to the Creation and Development of a New Authorization Concept Based on a Learning Process. In: C*omputer Applications In Engineering Education. September* 20, 2010. Published online on 20 September 2010, Available online: July 5, 2014.http://onlinelibrary.wiley.com/enhanced/doi/10.1002/cae.20477

Tirian G.O., Filip I., Proştean G. (2004) Adaptive Control System for Continuous Steel Casting Based on Neural Networks and Fuzzy Logic. In: *Neurocomputing, Elsevier.* Available online: July 5, 2014.

System Analysis and Decision Making: Reference Dictionary Volkova, V.N., Kozlov, V.N. (eds.). In: VysshayaShkola, Moscow, p. 23.

Tyukin, I.Yu.,Terekhov, V.A. (2008) Adaptation in non-linear dynamic systems. Moscow, p. 13.

Forrester, J.W. (1968) Principles of systems: text and workbook. Chapters 1-10. In: *Wright-Allen Press*, 383 p.

Tom, P. (2002) Structural Stability and Morphogenesis In: Logos, Moscow, 288 p.