[1.]Miroslav BOBREK, [2.]Zorana TANASIĆ, [3.]Goran JANJIĆ

SYSTEMS ENGINEERING METHODOLOGIES FOR STUDY PROGRAM DEVELOPMENT

[1.]Faculty of Mechanical Engineering, Banja Luka, BOSNIA & HERZEGOVINA

Abstract: The basic wiev of the scope of knowledge relevant to Systems Engineering, presented in the Systems Engineering Body of knowledge (SEBoK) is organized in to 7 Knowledge areas (KA): 1 SEBoK Introduction, 2 Foundations of Systems Engineering, 3 Systems Engineering and Management, 4 Applications of Systems Engineering, 5 Enabling Systems Engineering, 6 Related Disciplines and 7 Systems Engineering Implementation Examples. Knowledge areas point out on specific engineering methodologies useful for new product or services development, deployment and quality assurance during their life cycle. In this paper the study program is viewed as a product. Through the realization of the study program of higher education institution provides the necessary knowledge and competences for the students. By applying these methods, benefits are achieved at all stages of the life cycle of the study program with a particular focus on identifying the required knowledge and competencies. System engineering, as a growing scientific and applied field, offers integrative tools for the development of complex systems and which category includes the study program as a product of a higher education institution. The paper illustrates the basic approaches.
Keywords: Systems engineering, Knowledge generation, Competences, Study program

1. UNDERSTANDINGS MAIN INPUTS FOR STUDY PROGRAM DEVELOPMENT

Development and realization of study programs on higher education level, unlike previous levels of education, prepare students for practice in their professions. Therefore, it is useful to using learning methods which could be common in organizations for continuous of knowledge generation in a new circumstance. Process of the study program development essentially is engineering process in creating a new system (product) which have to take into account requests of main stakeholders and relevant standards. Forward are emphasized some of the concepts which should be to understand during process of study program development.

— **Understanding key theoretical concepts of the knowledge generation**

Contemporary knowledge management literature affirms some of key concepts and issues on theoretical (philosophical/psychological) level as well as on development of practical methods and tools for implementing in organizations. Key theoretical concepts are illustrated on figures 3 and 4, both of which based on learning process in organization.

Concept on Figure 1, [1] presents knowledge creation through the level of understanding considered problem (relations, patterns, principles).

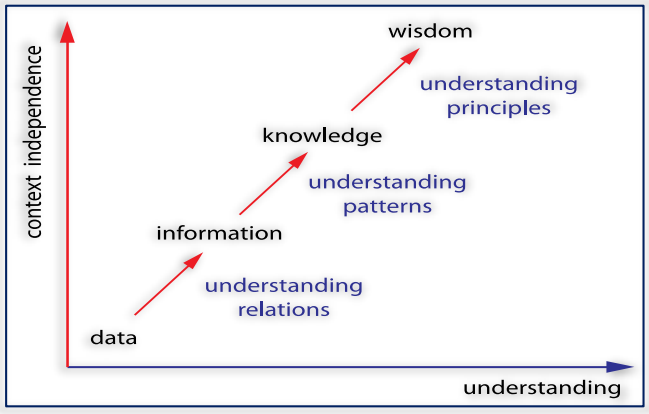

Figure 1. The main relations of knowledge

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665
Universitatea Politehnica Timişoara

Emphasising the significance of "understanding", the author of this scheme stresses:

≡ A collection of data is not information.
≡ A collection of information is not knowledge.
≡ A collection of knowledge is not wisdom.
≡ A collection of wisdom is not truth.

To put in other words, collecting data, information and knowledge has to be integrated through learning process in order to achieve understanding, wisdom and truth.

Figure 2, [2] illustrates the example of practical implementation in achieving professional competence in learning processes and systems. The main prerequisites for achieving Professional competence are:

≡ creating knowledge by learning through networking and finding right information,
≡ achieving ability through application of learned knowledge,
≡ meeting competence by motivation and volition for action in accordance with proper standards and
≡ becoming professional by social responsibility in functioning of organization.

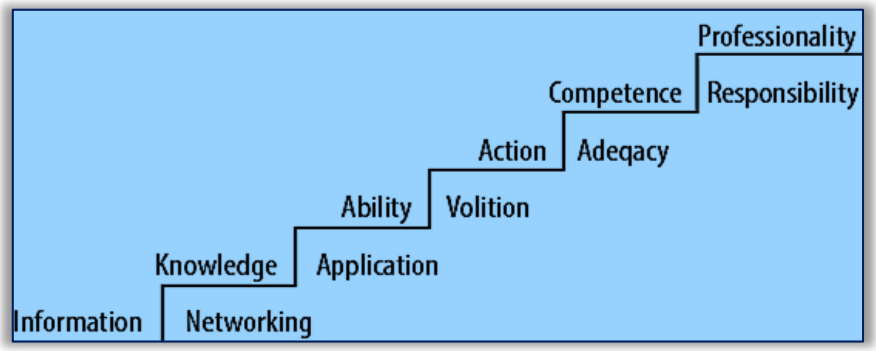

Figure 2. Steps for professional competences

— Understanding social needs for human resource development

With the aim of generating knowledge and support to all processes of learning and thus increasing the capacity of human resources at the national level, all national communities (countries) adopt appropriate policies and strategies. Such policies and strategies relate to both the educational as well as the real sector and in the integral sense make so called The Skills System. This system does not represent either one specific organization or body, but it functions as an ecological system, natural system with many participants operating in the same area, often based on competitive struggles for available resources and the realization of independent goals.

The basic intention of the Skills Development System is to establish social processes which should result in the creation of new jobs and the development of human resources as an active participant in social flows [36]. In many countries The Skills System is made up of a series of subsystems with highs the level of independence that should co–operate with each other. However, this cooperation it is often absent, and social mechanisms for its effective establishment are missing. This situation is particularly characteristic for the societies that undergo transition from one social system in a different way.

The basic elements or subsystems of the Skills System are:

≡ Educational system with its structure of pre–school, primary, secondary and higher education, vocational education and training systems, education adults and lifelong learning;
≡ Labor market links such as employment agencies, agencies for human resources development, unemployment support systems, and social systems protection;
≡ Social support systems for sensitive (vulnerable) social groups in inclusion in the educational system and working processes such as women, minority groups, disabled people, etc.
≡ Socio – economic systems that have a significant need for human resources and can affect the labor market, such as large companies, investors and other employment initiators through the development of entrepreneurship and the overall economic development.

— Understanding international standards of qualifications and occupations

International Standard Classification of Occupations (ISCO) is one of the main classification for whoever is responsible International Labor Organization – ILO. ISCO is a tool for organizing jobs

within clearly defined groups in accordance with the tasks and duties that are undertaken within the work. His basic goals are to provide:

- basics for international reporting, comparison and exchange of statistical and administrative data on occupations;
- models for the development of national and regional classifications of occupations and
- a system that can be directly used in countries that do not have developed own classification.
- International Standard Classification of Education – ISCED) is a statistical frame for organizing of informations about education, maintained by United Nations Educational, Scientific and Cultural Organization – UNESCO.

In order to facilitate the practical application of these and other international ones classification, is a very useful European initiative under the slogan "European Classification of Skills / Competences, Qualifications and Occupations – ESCO“ (Figure 3) [3].

Figure 3. ESCO model

2. SYSTEM ENGINEERING APPROACH TO PUT ALL TOGETHER

Systems engineering is "an interdisciplinary approach and means to enable the realization of successful (engineered) systems" [4]. It focuses on holistically and concurrently discovering and understanding stakeholder needs; exploring opportunities; documenting requirements; and synthesizing, verifying, validating, deploying, sustaining and evolving solutions while considering the complete problem, from system concept exploration through system disposal. An engineered system is an open system of technical or socio–technical elements that exhibits emergent properties not exhibited by its individual elements. It is created by and for people; has a purpose, with multiple views; satisfies key stakeholders' value propositions; has a life cycle and evolution dynamics; has a boundary and an external environment; and is part of a system–of–interest hierarchy.

The main assumption in this paper is that study program has all characteristics of an engineered system in the form of product offering by higher education institutions on the education market.

Martin [5] describes seven types of system, or "the seven samurai of systems engineering", all of which, system developers need to understand to develop successful systems:

- the context system
- the intervention system
- the realization system
- the deployed system
- collaborating systems
- the sustainment system
- competing systems

Martin contends that all seven systems must be explicitly acknowledged and understood when engineering a solution for a complex adaptive situation.

Relations between above mentioned types of systems in process of new product development Matin present by ontology concept (figure 4).

Designers of study program should understand, identify, elaborate and take into account all "seven samurai of systems engineering" and their interrelations in development process. In these approach Study program considered as a product is presented as a Intervention system (S2) created and developed in Higher education institution – Realization system (S3) which have intention to solve Problem (P1) generally defined as lack of competent human resources on market – Context system (S1).

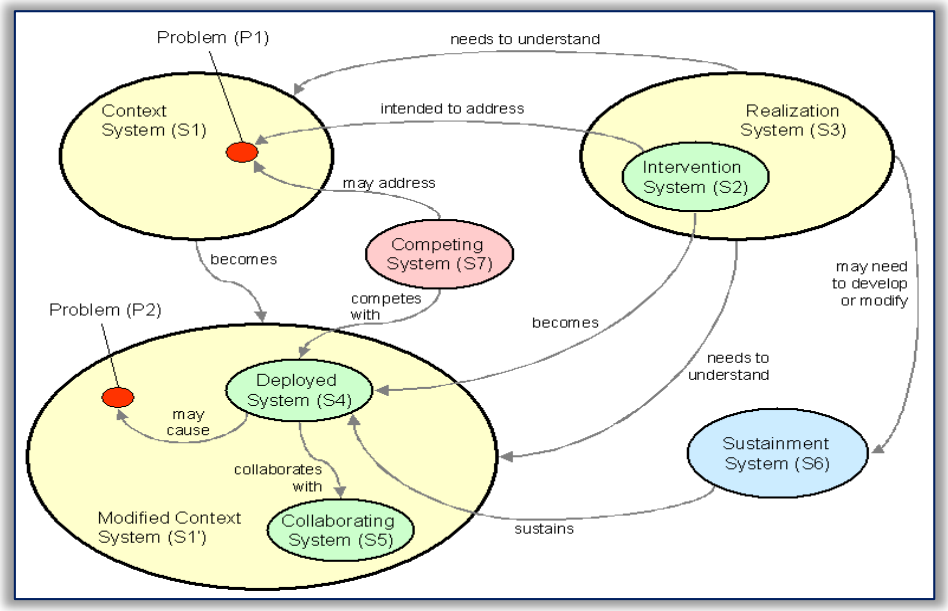

Figure 4. Product Sustainment System in Support of the Deployed Product System

3. CONCLUSION

The development and realization of study programs based on identified needs and requirements of stakeholders is one of the main objectives of the reform of higher education within the Bologna Process. The implemented processes of self–evaluation, external evaluation and accreditation of higher education institutions in the Republic of Srpska point to a significant level of inertia in these changes. There is a similar impression in the higher education systems of the countries in the region. This work wishes to point out the importance of concepts and tools of system engineering in accelerating these processes of change.

Note:

This paper is based on the paper presented at DEMI 2019 – The 14th International Conference on Accomplishments in Mechanical and Industrial Engineering, organized by Faculty of Mechanical Engineering, University of Banja Luka, BOSNIA & HERZEGOVINA, co–organized by Faculty of Mechanical Engineering, University of Niš, SERBIA, Faculty of Mechanical Engeneering Podgorica, University of Montenegro, MONTENEGRO and Faculty of Engineering Hunedoara, Unversity Politehnica Timisoara, ROMANIA, in Banja Luka, BOSNIA & HERZEGOVINA, 24–25 May 2019.

References

[1] Gen Bellinger, Knowledge Management – Emerging Perspectives, http://www.systems–thinking.org/kmgmt/kmgmt.htm, used Feb. 2013.
[2] North, K.; Reinhardt, K.; Kompetenzmanagement in der Praxis, (2005)Gabler Verlag, Wiesbaden,.
[3] European commission, (2013) European Classification of Skills/Competences, Qualifications and Occupations, Luxemburg
[4] INCOSE. (2015). Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, version 4.0. Hoboken, NJ, USA: John Wiley and Sons, Inc, ISBN: 978–1–118–99940–0
[5] Martin, J, (2004), The Seven Samurai of System engineering: Dealing with the Complexity of 7 Interrelated Systems. Proceedings of the 14th Annual INCOSE International Symposium, 20–24 June 2004, Toulouse, France.

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665