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APPLICATION OF ANALYSIS AND RISKS ASSESSMENT METHODS FOR QUALITY ASSURANCE AT THE UNIVERSITY

On the example of the National Metallurgical Academy of Ukraine the authors have identified the risks in the university activities using the recommendations of ISO 9001:2015 and ISO 31000 series and applying the known methods for analysis of the essential aspects of organization functioning (PEST-analysis, SWOT-analysis, SNW-analysis). The assessment of significance of these risks using FMEA system enabled the authors to determine the appropriate immediate safety measures.

Keywords: higher education, risk identification and measurement, and precautions.

The world practice testifies to the expediency of taking account of the requirements to the quality system, as set forth in ISO 9000, 14000, 26000, OHSAS 18000 series and the others, in the activities of organizations, in particular from the perspective of constant development and improvement of these documents [1].

In this sense, publication of new revised basic standard ISO 9001:2015, preparing the corresponding DSTU ISO 9001:..., development of system of standard documents ISO 31000 series and others requires the priority actions, in particular identification and consideration of risks in the activities of organizations [2 (section 05; 4, paragraph 4.4.2; section 5, paragraph 5.1.2; section 6, paragraph 6.1; section 10, paragraph 10.2), 3, 4]. In addition to the above, the term «risk» is defined in ISO 9001:2015 [2] as «impact of uncertainty on the expected result» and «risk management» as «coordinated actions on direction and management of organization relating the risks».

Such measures for the education sphere greatly depend on the context (i.e. on living conditions of organization) and on one of the basic features of focused sphere: people act as customers, consumers and (what matter is!) as a subject of transformation. Specifically, their peculiar properties, dedication and opportunities that affect the implementation process at all stages of life cycle of educational services determine the increased level of risk. The above said is fully consistent with the provisions of the Law of Ukraine of July 1, 2014, No. 1556-VII «On Higher Education» which defines the contours of quality system for the educational activities.

The aim of this work was to analyze risks on the example of the National Metallurgical Academy of Ukraine (NMetAU) from the standpoint of their potential developing processes and possible preventive actions within the internal quality assurance system of higher educational institution (HEI).

Conventionally, all risks can be divided into the external and internal ones.

The external risks are determined by a set of environmental circumstances. They cannot be changed or eliminated by the efforts of organization. This requires monitoring and innovative management response [6]. The internal risks depend

on the processes in the higher educational institutions and are directly connected with the activities of staff [7].

In the course of investigations, with the NMetAU specificity taken into account, PEST-analysis, SWOT-analysis and SNW-analysis approaches were used, as well as recommendations of standards DSTU IEC/ISO 31010:2013 [4], ISO/TR 31004:2013 [10] and methodology of *FMEA* [10, sub-section B.13; 11; 12] system.

PEST-analysis is an instrument used to mainly detect *Political* (*P*), *Economical* (*E*), *Social* (*S*), and *Technological* (*T*) external factors affecting the organization [13].

Table 1 shows the results of identification of major external factors impacts on the NMetAU activities.

In addition, the impact of external factors on the internal risks with the opportunities to manage the latter led to the use of SWOT-analysis

Table 1

Results of PEST-Analysis of External Factors Impact on the NMetAU Activities

Factors	Factors	Threats (Risks)
Political	1) European integration progress of Ukraine; 2) perception of Ukraine by the world community as a country with basically agricultural economy; 3) trends in the national military-political and economic situation; 4) increased demands as to HEI quality and reduction of their quantity; 5) change in the legal framework of education in Ukraine, including aspects of quality assurance; 6) using the system of rating evaluation of HEI.	1) Fragmentation of scientific and educational ties with foreign universities; 2) negative impact of «provinciality of location» on the competitive properties; 3) unfavorable distribution of state budget funds for the educational process; 4) insufficient demand in the NMetAU potential by businesses of the region; 5) inadequacy of the material and technical resources of educational and scientific activity to up-to-date requirements; 6) increased competition in certain specialties; 7) difficulty in forecasting, planning and development of various fields of educational activities.
Economic	1) inflation; 2) decline in production; 3) privatization of enterprises; 4) residual principle of education funding; 5) competitive public procurement system.	1) reduction in the education funding; 2) reduction in public orders and target training of graduates; 3) slowdown in update and spread-out of material and technical resources of HEI.
Social	1) general low level of populations' social maintenance; 2) saturation of the labor market with the graduates of certain professions; 3) increasing the social value of higher education documents; 4) aggravation of demographic situation; 5) quality degradation of pre-university education.	1) reduction in the number of potential entrants; 2) reduction in the public interest in engineering professions; 3) low level of material security of academic teaching staff; 4) young qualified personnel deficit.
Technological	1) convergence of higher education systems in Ukraine, Europe and the World, in particular under the principle of continuity of education and development of HEI autonomy; 2) introduction of information and innovative technologies in the educational, scientific and social spheres of HEI.	1) inadequacy of the material and technical resources of HEI to up-to-date requirements; 2) a large amount of regulatory guidance documents of central government.

[13] with consideration of strong (*Strengths, S*) and weak (*Weaknesses, W*) aspects of activities, favorable opportunities (*O*) and threats (*T*), as reflected in Table 2.

A more detailed assessment of strengths and weaknesses of internal potential of NMetAU was made using SNW-analysis [13] in «the coordinates» of categories identification: «strength» (*S*), «neutrality» (*N*) and «weakness» (*W*), as reflected in Table 3.

The assessment of risks was carried out with a combination of their probability and consequences of disadvantage [13]. Thus, the probability of adverse effects can be defined qualitatively (verbally) and/or quantitatively (probability ratio *p*). For example, «*constantly — often*» — $p = 1...10^{-1}$; «*often — accidentally*» — $p = 10^{-1}...10^{-2}$; «*accidentally — rarely*» — $p = 10^{-2}...10^{-4}$; «*rarely — unlikely*» — $p = 10^{-4}...10^{-6}$; «*unlikely — fabulously*» — $p < 10^{-6}$. Then seriousness of the consequences can be qualitatively classified as catastrophic (*C*), high (*H*), essential (*E*) or minor (*M*).

Quantitative risk assessment has been carried out according to FMEA method [11, 12]

Table 2

Results of *SWOT*-Analysis of the NMetAU Activities

Strong aspects of activity	Weak aspects of activity
1) NMetAU is a leading national institute of the region, state-owned legal entity with "monopoly» status in certain specialties; 2) fruitful connectivity with some foreign universities; 3) relationship of education with basic and applied research; 4) sufficient level of corporate, technical, educational, scientific and cultural information; 5) a relatively high level of skills development; 6) provision of end-to-end higher education at all levels (from junior bachelor to doctorate); 7) a minimum acceptable level of logistical base in specific areas of training the specialists and research implementation; 8) mostly positive reputation among the consumers of educational services	1) limited external international and cultural relations; 2) inadequate marketing of regional market of labor and scientific research implementation; 3) inadequate funding of educational and scientific programs; 4) inadequacy of the level of material and technical resources to up-to-date requirements in certain specialist training programs and implementation of research; 5) insufficient demand for graduates of certain professions by entrepreneurs of the region; 6) lack of the effective system of incentives and promotion of educational activities.
Favorable opportunities	**Threats that cause risks**
1) Fruitful cooperation with domestic and foreign universities; 2) development of universities autonomy; 3) meeting the real demand for quality educational services; 4) use of high technology and special production in the region as a base for partnership links, orders of educational and scientific services; 5) use of innovative technologies in educational, scientific, technical and socio-economic processes; 6) implementation of information technologies for education and science; 7) expanding the list of specialties for training at all levels of education and providing the additional educational services	1) low predictability and high rate of change in the legal framework of activity; 2) insufficient level of state funding of activities and material and technical resources; 3) inadequacy of material and technical resources of educational and scientific activities to up-to-date requirements; 4) increased competition in all types of activities; 5) low demand in HEI scientific potential by the entrepreneurs of the region; 6) aggravation of demographic situation and reducing the number of potential entrants; 7) ageing of university faculty and shortage of young skilled personnel; 8) all-round decline in the quality of pre-university education

using the definition of «risk priority number» (RPN):

$$\text{RPN} = S \cdot F \cdot D, \quad (1)$$

where $1 \le S \le 10$ — importance (score) of the most serious consequences of potential threat (risk) for the object; $1 \le F \le 10$ — reflects the probability of a particular risk: 1 — for very rare emerging threats (at $p \le 10^{-4}$) and 10 — for the constant risks (at $p \ge 10^{-1}$); $1 \le D \le 10$ — score of the potential defect or reasons for its occurrence: 1 — for risks that are almost reliably detected (for example, in forecasting the number of students with demographic phenomena taken into account) and 10 — for risks that cannot be practically detected (for example, in forecasting the number of studying seats received under a public contract).

According to RPN coefficient one can determine which risks are most significant and therefore, for which of them you should take precautions. The components of this value are defined by the expert estimation and compared with a critical value of RPN_{cr}. The last parameter can be determined from the following considerations:

- «Very low», «low» or «significant» effects of risk are correlated with values S 4, 5 and 6, respectively [11, Table 2].
- The substantial probability 10^{-3}, $2 \cdot 10^{-3}$ or $5 \cdot 10^{-3}$ of certain risk occurrence is correlated with values F 4, 5 and 6, respectively [11, Table 3].

Table 3

Results of *SNW*-Analysis of the NMetAU Inner Potential

Position	Evaluation position		
	S	N	W
1. Marketing:			
1) NMetAU position in higher education and scientific research;		×	
2) diversification of educational programs according to the needs of the labor market;	×		
3) demand for the NMetAU graduates by the entrepreneurs of the region;			×
4) NMetAU reputation among the businesses of the region	×		
2. Research work:			
1) level of logistics base;			×
2) innovative technologies in research activities	×		
3. Production (services):			
1) fundamentality of academic education;	×		
2) level of educational materials and information systems software;	×		
3) level of logistics base;			×
4) innovative technologies in the educational activities	×		
4. Finances:			
1) current account of the balance of payments;		×	
2) availability of investment resources			×
5. Personnel:			
1) level of the NMetAU human capacity;		×	
2) system of personnel training;	×		
3) system of personnel incentives based on the results of the work			×
6. Management:			
1) organizational management structure of the NMetAU;	×		
2) system links of the NMetAU with the businesses of the region		×	

Table 4

Risk Assessment and Measures to Prevent Them in the NMetAU Activities

No	Risk area	Risks	*S*	*F*	*D*	RPN	Risk management measures with consideration of	
							Available opportunities	Necessary innovative decisions
External circumstances								
1	Political	Neglect of the national HEI achievements by the world community	7	8	3	168	1) development of links with foreign universities; 2) development of the HEI autonomy in compliance with the principle of openness and transparency; 3) providing the end-to-end higher education at all levels and forms of education; 4) advertising of achievements and corporative culture; 5) reconciliation between the graduates competence and needs of potential customers	1) monitoring of political situation in the country and the world, in general and in particular, in education; 2) competent marketing policy under conditions of HEI monopoly in the specific fields of activity and benefits of state-owned property
2		Impact of «provinciality of location» on the HEI competitive properties	4	10	2	80		
3		Changes in the labor market; insufficient demand for the HEI scientific potential by businesses of the region; HEI competition	8	8	2	128		
4	Economic	Negative trends in the country's economy and unfavorable disposition of state funding	10	7	3	210	1) creation and implementation of effective quality system in accordance with ISO standards; 2) development of target training of specialists for the needs of regional enterprises; 3) development of all forms of education	1) initiation of industry innovation fund revival to support research; 2) forecasting the inflation in determining the necessary amount of extra-budgetary funds and cost of contract training
5		Reduction in state funding of HEI education and research	10	7	4	280		
6	Social	Aggravation of demographic situation and reduction in the number of potential entrants	7	6	7	294	1) implementation of measures relating the pre-university training of entrants; 2) aggressive advertising campaign, as well as agitation and explanatory work	1) use of measures to strengthen the HEI competitive positions (participation in the activities of structures of central management and government, PR-campaign); 2) search and attraction of grants in the sphere of social responsibility
7		Reduction in public interest in engineering professions	5	5	7	175		
8		Low level of material security of academic teaching personnel	5	5	5	125		

Continuation

No	Risk area	Risks	*S*	*F*	*D*	RPN	Risk management measures with consideration of	
							Available opportunities	Necessary innovative decisions
9	Technological	Moral and physical wear and tear of logistics base of HEI	4	4	8	128	1) IT development and computerization of educational and scientific technology; 2) integration of resources capacity of HEI units, formation of technology parks, involving several institutions and universities	Integration of resource capabilities of several institutions and interested scientific and industrial organizations in the region
10		Too large volume of documentation flows	3	4	7	84		
Internal circumstances								
11	Marketing	Low demand for the NMetAU graduates by businesses of the region	7	6	6	252	1) active promotional policy of the establishment; 2) development of target training of specialists for all forms of education; 3) strengthening of cooperation with parents of future students	1) reconciliation between the graduates competence and needs of customers; 2) development of incentive programs for entrants
12	Management	Formalization of management processes	3	5	2	30	1) development of efficient quality system of HEI; 2) fight against corruption; 3) creation of favorable conditions for activities	Use of innovative and PR-technologies in the educational, scientific and socio-economic processes
13		Decline in the level of image on the part of potential customers of services	6	6	5	180		
14	Supply of resources (material, financial, staff, intellectual, informational, etc.)	Loss of current balance equilibrium	5	5	3	75	1) efficient allocation of budget costs; 2) formation of reserve money for the foreseen and unforeseen expenditures; 3) personnel development system	1) optimization of economic services; 2) search of sponsors among stakeholders; 3) application of educating methods; 4) stimulation to the personnel professional development connected with achievements
15		Inadequacy of material and technical resources of educational and research activities to the up-to-date requirements	4	4	8	128		
16		Ageing of academic teaching staff	7	8	2	112		
17		Reduction of student cohort	10	7	2	140		
18	Quality of rendered educational and research services	Deterioration in quality of education.	6	6	2	72	1) target training on real subjects; 2) expansion of practice base list; 3) development of educational and methodological, as well as information support	1) ensuring communication of education and fundamental and applied researches; 2) implementation of measures as to logistics base for researches
19		Shortage of young high-quality staff	8	8	3	192		
20		Degradation in research quality	7	7	3	147		
21		Risk of status and license loss	10	3	7	210		

- High, substantial or significant possibility of identifying the risk is correlated with values *D* 3, 4 and 5, respectively [11, Table 4]. Then according to formula (1) RPN_{cr} = 48...180.

In practice, value $30 < RPN_{cr} < 50$ is set for the important processes and products of responsible destination (for example, parts of complex equipment) whereas value $RPN_{cr} \geq 100$ [14, 15] for the appliances of unweight destination. Thus, derating of RPN_{cr} should provide more high-quality and reliable facilities. As an example, according to the data [11, Table 1] and [5], value $RPN_{cr} = 70$ in the production of components of automobile engineering does not require precautions, whereas value RPN_{cr} = 112 requires preventive measures. These data became also the guidelines in determining RPN_{cr}.

For specific conditions the NMetAU performed the expert assessment of results of interviewing 15 senior representatives from the universities and educational commissions and checking of data consistency at a rate of concordance when compared the latter with the critical value χ^2-criterion [15]. Representativity of the given assessment is provided with the analysis of all aspects of HEI activities.

As a result, according to tables 1—3 data for the main risks in the NMetAU activities RPN was calculated versus the simultaneous level definition of RPN_{cr} = 100...150, which made it possible to identify the rational risk management with both existing and necessary affordable innovative measures taken into account (see, Table 4).

These data enabled us to determine the ***basic*** risks, RPN of which outweighed RPN_{cr} value: positions 1, 4, 5, 6, 7 (external risks) and positions 11, 13, 17, 19, 20, 21 (internal risks), as well as a number of immediate preventive measures used in the NMetAU to neutralize a potential loss from inconsistences.

CONCLUSIONS

On the example of external and internal factors of the National Metallurgical Academy of Ukraine functioning with the consideration of recommendation of ISO 9001:2015 and ISO 31000 series standards and using the known methods of identification and evaluation of risks weight the authors have defined the most problematic aspects of activities and immediate measures to cut losses. The suggested approach and the above-mentioned specific measures can be useful for the improvement of activity in other higher educational institutions, as well.

REFERENCES

1. *Dolzhanskyy A.M., Ocheretna N.M., Lomov I.M.* Quality management and quality management systems. Dnepropetrovsk: Svidler A.L., 2011 [in Ukrainian].
2. *ISO 9001:2015*. Quality management systems — Requirements. Electronic resource. 2015-09-15. — 29 c. Access mode: http://www.iso.org/iso/catalogue_detail?csnumber=62085.
3. *ISO 31000:2009*. Risk management — Principles and guidance. Electronic resource. Access mode: http://www.iso.org.
4. *DSTU IEC/ISO 31010:2013*. Keruvannya rizikom. Metody zagalnogo otsinyuvannya riziku (IEC/ISO 31010:2009, IDT); 11.12.2013 p., N 1469. Kyiv: Mineconomrozvitku, 2015 [in Ukrainian].
5. *Volkov O.I., Vitkin L.M., Khimicheva G.I., Zenkin A.S.* Quality systems of higher education: Theory and Practice. Kyiv: Naukova Dumka, 2006 [in Ukrainian].
6. *Yelesina A.A.* Mechanizm upravlinnya zovnishnimy rizikamy VNZ. *Biznessinform (Business inform)*. 2012. 9: 315—318 [in Ukrainian].
7. *Sergeyeva L.N., Yelesina A.A.* Osoblivosty vnutrishnikh rizikiv VNZ z tochky zoru upravlinnya. *Visnic Zaporizkogo natsionalnogo universitetu (Bulletin of Zaporizhzhya National University)*. 2012. (15): 140—147 [in Ukrainian].
8. *Miroshnikov V., Gorlenko O.* University typical quality system: Introduction Recommendations: tutorial. Bryansk: Publisher of Bryansk State Technical University, 2003 [in Russian].
9. *Minazheva G.S.* Development, implementation and improvement of the quality management system in higher educational institutions of Kazakhstan: Scientific-practical publication. Almati: Kazak Universitetyi, 2009 [in Russian].
10. *ISO/TR 31004:2013*. Risk management — Guidance for the implementation of ISO 31000. Electronic resource. Access mode: http://www.iso.org.
11. *Potentional* Failure Mode and Effects Analysis (FMEA). DaimlerChrysler Corporation: Ford Motor Company: General Motors Corporation, 2001.
12. *IEC 60812:2008*. Analysis techniques for system reliability — Procedure for failure mode and effects analy-

sis (FMEA). Electronic resource. Access mode: http://www.iso.org/iso/catalogue.
13. *Akhmetov K.S.* Risk Management Practice. Moscow: Russkaya Redactciya, 2004 [in Russian].
14. *Bagimov I.A., Taranenco V.A.* Primeneniye apparata nechetkoy logikyi dlya otsenkyi prioritetnostyi chisla riska v metodologiyi FMEA Electronic resource. Access mode: donntu.edu.ua/russian/konf/mashinebuild/arhiv/vipusk32_2006.pdf.
15. *Orlov A.I.* Non-numerical statistics. Moscow: MZ-Press, 2004 [in Russian].

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ЗАСТОСУВАННЯ МЕТОДІВ АНАЛІЗУ ТА ОЦІНКИ РИЗИКІВ В ДІЯЛЬНОСТІ ВИЩОГО НАВЧАЛЬНОГО ЗАКЛАДУ

З урахуванням рекомендацій стандартів ISO 9001:2015 та ISO серії 31000 при застосуванні відомих методів аналізу суттєвих аспектів функціонування організації (PEST-аналіз, SWOT-аналіз, SNW-аналіз) ідентифіковано ризики у діяльності університету (на прикладі Національної металургійної академії України). Оцінювання значущості цих ризиків з використанням системи FMEA дозволило визначити відповідні першочергові запобіжні заходи.

Ключові слова: вища освіта, ідентифікація та вимірювання ризиків, запобіжні заходи.

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ПРИМЕНЕНИЕ МЕТОДОВ АНАЛИЗА И ОЦЕНКИ РИСКОВ ПРИ ОБЕСПЕЧЕНИИ КАЧЕСТВА ДЕЯТЕЛЬНОСТИ ВЫСШЕГО УЧЕБНОГО ЗАВЕДЕНИЯ

С учетом рекомендаций стандартов ISO 9001:2015 и ISO серии 31000 при использовании известных методов и анализа существенных аспектов функционирования организации (PEST-анализ, SWOT-анализ, SNW-анализ) идентифицированы риски в деятельности университета (на примере Национальной металлургической академии Украины). Оценивание значимости этих рисков с использованием системы FMEA позволило определить соответствующие первоочередные предупредительные меры.

Ключевые слова: высшее образование, идентификация и измерение рисков, предупредительные меры.

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