

How to Support Monotown Industries with Advanced Professionals: Information Model as a Tool for Individual Education Route Design

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Abstract. For many years company towns, or monotowns (i.e. their Russian designation), have been crucial issues for federal and local governments from the point of view of monotowns' economies diversification, and social and enterprise restructuring. One of the most significant changes may come from industry-university collaboration that is one of the efficient instruments to commercialize professional education and make it work for the needs of monotowns economies. The authors have analyzed the literature on the relevant topics and have come to a conclusion that it is necessary to gather and set information on education and employment opportunities, from and for all stakeholders, into a unified domain. This domain should contain formalized information, and support industry-university collaboration with a novel conceptual model of decision support system. The key outcome of the study is an informational model for individual education route design that synthesizes stakeholders' needs, requirements and demands, and suggests information on education and employment opportunities in the conditions of a monotown economy. Upon the obtained results further investigations of decision supports systems as a tool for individual education routes design will be carried out.

1. Introduction

Monotowns, also known as company towns or single company towns, are urban settlements that grew around a single plant or factory. In the times of the Soviet Union Soviet planners created them at rational locations in the areas rich with natural resources. Some of the monotowns of Siberia appeared in the times of World War II when industrial enterprises, previously located in the western part of the country, were moved eastward in the attempt to defend them against the Nazi onslaught. Russian planned settlements grew rapidly after the WWII, many in geographical unfriendly regions. One of the specific features of any monotown is spatial division of labour, which meant maximum regional specialization in some types of production within national economy, underpinned by military, strategic, political and economic rationale. Hence, monotowns present crucial issues for federal and local governments from the point of view of diversification and social and enterprise restructuring.

Monotowns are not Russian specific; many European countries have experienced cities' transformations as their development policy, i.e. replacement of industries in Glasgow (UK), restructuring declining industrial city of Pittsburgh (USA), or adapting depopulated and downsizing East German cities to new social, economic and political circumstances [1].

The 2014 Russian government decree classified ninety four monotowns- territories of advanced social and economic development (TASED, authors' abbreviation) as those with very acute social and economic situation, meaning they are close to economic collapse or bankruptcy. A Fund for the Development of Monotowns was also established in 2014 with the purpose to invest in infrastructure and promote economic diversification and business climate that comprises the attitude of the government, policy makers, labour organizations, and financial institutions toward businesses, to become competitive with the key business centres of the Pacific Asian countries [2]. For the enterprises located in monotowns, it is of urgent importance to extend the assortment of goods and services they produce, find new markets, and master new means of production to become efficient, gain economic benefits, and, thus, avoid bankruptcy. In this relation, regional and local authorities should consider the need of enterprises in competent specialists that are capable of working with innovative technologies and computer software; professionals that are able to solve present time problems as well as forecast for the future. Russian educators call this approach in teaching specialists as *operezhayushchaya podgotovka/operezhayushchaya podgotovka*, which might be translated into English as *advanced teaching*, or *anticipatory teaching*, which means teaching competencies that might be highly demanded in the nearest future. Hence, the term *advanced professional*, we use in the paper; this is a Russian designation for specialists that are ready to deal with state-of-the-art technologies, and are capable of quick professional development, or transformation.

Teaching engineering students through the advanced teaching approach requires efficient cooperation of all the stakeholders, namely, policy makers, educators, and representatives of factories, plants and businesses, who are responsible for staff enrollment or further education at their enterprises, and students. It is also important to provide academic institutions with digital support, i.e. decision support systems, also known as computer programs that can arrange or sort large amounts of data, and, thus, help people in companies and organizations make important decisions based on relevant data. Therefore, with this paper we stress the necessity to develop a methodological ground that will provide digital monitoring and herald the era of decision support systems in education; i.e. systems that have potential to identify regularities in industrial, economic, entrepreneurial and social spheres, and forecast trends in teaching specialists for monotown industries.

Talking about complex challenges monotowns face, it is important to mention migration of economically active residents to territories with developed economy, hence, opportunities to realize professional competencies and career plans. In this connection, it is necessary to understand how people make decisions about their education routes or career paths. Firstly, this process is usually influenced by a great number of subjective and objective factors, personal aims or interests, and opinion of other people. Secondly, educational outcomes of any academic program or individual route, a person chooses, might be important not only for a person, who undertakes the program or an individual set of courses, but also for all people, organizations, academic institutions, or enterprises which form both educational and labour markets. Finally, regional and local authorities of monotowns also benefit from career opportunities that residents obtain when they design their own education routes; it is impossible to adapt declining cities to new social and economic conditions, if not restructure labour market and reverse a reduction of economically active residents.

Thus, it is of burning importance to develop collaboration between all the stakeholders (students, academic institutions, employers, regional and local authorities, or communities) (i.e. industry-university collaboration) who might be engaged directly or indirectly into education issues, and influence the decision people make while designing their individual education routes.

The purpose of the paper was to show that it is important to arrange industry-university collaboration to influence the advanced teaching of specialists for monotowns industries; this will help create a unified informational domain for people who want to design their individual education routes; that data system analyses can be successfully applied to decompose individual education route design into several key stages; then to reveal basic data streams and analyze their interrelations within different stages – when we monitor, study, chose or evaluate the outcomes we obtain by the end of a program or a set of courses; the evaluation is to be done from the point of view of all the stakeholders;

and, finally, to make an information model for individual education route design. The model should provide a conceptual approach to database design, network stakeholders, facilitate teaching professional and general competencies to students, and help evaluate results from the point of view of all the beneficiaries.

2. Methods and approaches, applied to create decision support systems for professional education: individual education route design

The key factor for a monotown economy development is the quantity and quality of specialists engaged into production of goods and services. Today, the level and speed of scientific and technological development and globalization of national economies demand specialists of higher standard, who are capable of lifelong learning, or of changing professions or specializations they have at any period of their work life. In this regard, it is of high priority for each person to have an opportunity to decide what, where, how, how long and how often to learn or practice (i.e. individual education route or trajectory). These decisions are strategic in their nature as soon as they are directed towards the benefits a person gets in future; they require a substantial amount of personal, financial and time resources, and the output determines personal success. Quality information support helps a person make the most satisfactory decision.

Today, educational market worldwide is overextended with various offers of formal, informal, online and other programs or courses; in the situation of large surpluses people should have a tool to help them make decisions about what program to choose, or what education route to design.

For this purpose, it is necessary to create a multi-purpose system that will allow all the stakeholders evaluate programs or courses from the point of view of their needs and requirements. For example, a person, when he/she needs to choose a program, course, or set of courses, appreciates it if it fits his/her lifestyle, teaches necessary competencies, improves his/her competitiveness, and enlarges employment opportunities. To evaluate programs from all the factors mentioned above, person needs information on a program relevance to labour market demands, i.e. each program or course should have been evaluated by both academic institution and a potential employer. At the same time, available job vacancies have various degrees of popularity among potential employees which depend on work conditions employers suggest; this means that academic institutions or potential employees can evaluate offers. Thus, those employers, who consider the strategy for the development of monotowns, which is based on the diversification of their economies, investment and job/work places creation, can use development forecasting approach when they employ new personnel or retrain their staff; together, residents of monotowns, being aware of the needs and perspectives of the area they live in, know exactly where to find information on criteria they should consider to design their education route or choose educational program [3].

In this way, lack of methodological and informational ground for decision support system factors in the absence of decision making tools that combine needs and concerns of all social partners [4, 5].

In this paper it is important to mention basic research works, which are relevant to the problem of the paper. Russian and international (i.e. non Russian) educators observe different teaching and training aspects in connection with individual education routes and industry-university collaboration. Based on the review of existing literature, the authors identify core problems educators address to; they are – learning programs and individual curriculum design [6, 7], evaluation of labour market demand for qualified specialist [8], academic institutions assessment, including education quality control [9, 10, 11, 12], advanced professional training, including retraining of specialists and refresher training [13], program choice criteria [14, 15], industry-university collaboration in programs design and their [16]. Authors emphasize the importance of considering today's and future needs and requirements of industries and businesses when designing educational programs. This requires creating tools that will help monitor labour market, and elicit qualification and competency requirements that enterprises and businesses impose on their employees.

Industry-university collaborations have received great attention in educational management practice and research. Some investigators give particular importance to correlation between

requirements, employers impose on their potential workers, and educational standards; they claim that this kind of agreement is the only efficient way to elicit professional competencies and design programs and courses that will fit all stakeholders [17]. The ambition of policy makers and academic institutions is to develop teaching through continuing education programs, including on-the-job training periods, patenting, and science parks or incubators [18].

Authors, that evaluate competitiveness of academic institutions, suggest models that help evaluate educational programs from the point of view of students' satisfaction [8].

Authors also describe problems that concern internal and external assessment of quality of education provided by different academic institutions. They say that the key criteria for this kind of assessment should be the level of satisfaction all stakeholders get while taking up programs, or teaching students, or examining and testing professional competences with potential employees. Students get satisfied when they realize that professional competencies they obtain create good employment opportunities for them [19]. Educators demonstrate their good will to work with students and collaborate with representatives of enterprises or businesses when they have all the cutting edge teaching and training resources, when they have opportunities to refresh their own professional knowledge and advance their own education to fit high standards of university professors or lectures. Universities also benefit from additional funding, from access to industry equipment or from licensing or patenting income [20]. Enterprises and businesses value those academic institutions, which graduates show themselves suitable for the positions they apply to; i.e. they pass on the job checks, and start working without any additional period of training or retraining. Companies profit from highly qualified human resources such as researchers or students [21]; they get access to technology and knowledge; and they can use expensive research infrastructure [22]. Authors make a conclusion that free publicity of academic institutions assessment results is necessary to make quality control reliable.

The development of Degree and Higher Level Apprenticeships (D&HLAs) heralds a new approach to collaborative working between universities, employers, students, professional bodies and independent training providers. The focus on collaborative working means that the new programs must fulfill a variety of different stakeholder expectations. Researchers explore the challenges and opportunities of designing and delivering D&HLAs from a multi-stakeholder perspective [23, 24, 25, 26, 27].

With this regard, some Russian authors demonstrate models that help educators determine if students' competences correspond to Federal State Standards for Education and potential employers' requirements.

Russian educators pinpoint the problem of imbalance which exists between Russia's Federal State Standards for Education and requirements imposed by Professional Standards; this incompatibility decreases graduates' employment opportunities, and arouses discontent among stakeholders. Authors suggest that a competency model of a graduate should be advanced through the so called context-competency approach and functional analysis of future practice, where professional context influences students' learning [28].

In light of these effects, it is important to ensure efficient management of education. In this regard, educators discuss how to automate educational management in domains which elements might be functions, i.e. assume numerical values; e.g., Automated Informational System for Basic Educational Programs Design that contains a domain with employers' requirements and demands to be considered when designing educational programs for universities [19].

Student centered approach is also among the subjects which are of high priority among educators. They emphasize the importance of communicating all the relevant information, concerning academic institutions, programs and their alternatives, to universities enrollees [6].

To conclude, it is important to state that there is a lack of research works, which study the issues of decision support systems in education, exactly there is lack of attention researchers pay to ways decision support systems might be used to help people design their individual education routes in the conditions of integrated environment, the ones, which help consider needs and demands of universities, employers, students and policy makers.

In this paper we have to declare our concern over the fact that most studies do not address issues of teaching advanced professionals for monotown industries.

The theoretical contribution of this paper consists of a new conceptual model we elaborated from our review on literature and which we use to organize factors of successful individual education route design.

3. Information Model as a Tool for Individual Education Route Design: Industry-University Collaboration in Teaching and Training Advanced Professionals for Monotowns

To answer our research questions we derived eight features typical to decision making in individual education route design; they are:

1. Individual education route (trajectory) is a lifelong and step-by-step process of gaining professional knowledge and skills, i.e. professional competences.

2. Individual education route is not static in its nature. It can change, being influenced by various objective and subjective circumstances. The environment can also have an impact on decision making. It can refer to support regional and local authorities provide, legal procedures or the market environment [25].

3. When learning, people address different educational programs of different levels, forms and content.

4. Individual education route is a concern of many groups that might be involved into education, or have their beneficial interests, like students themselves, academic institutions, employers, communities, regional and local authorities, policy makers, etc. Thus, it is important to consider their interests, needs, demands and requirements when we evaluate different alternatives.

5. Informational content in decision making domain presents a kind of a patchwork, i.e. only some fragments of information are available, but they are also disorganized, and do not give full, actual and reliable information that people or organizations may use to make their decisions.

6. It is still difficult to range alternatives and choose optimal ones, when there are no unified criteria or assessment instruments and methods.

7. People or organizations still use just expert judgment or other people's opinion, when they decide to opt for this or that alternative.

8. It is necessary to develop a set of web-centric tools (i.e. applications or systems that have been designed for the Web) to measure students' current achievements, and correct the trajectory when it is needed.

In this regard, it is important to create a complete and adequate informational domain for decision-making, people and organizations might use to choose education route; domain that will be relevant to current and predicted trends of labour and education markets. To create this information domain, it is necessary to develop a system of comprehensive mutual evaluation of education routes, based on information received from all the stakeholders who can influence the decision people make.

Educators devote considerable effort to finding informational models and creating web-centric decision support systems for those who start design their education routes. The main purpose of this system should be to provide the stakeholders with informational domain to support them with all the digital decision making tools; this also supports the idea of industry-university collaboration where different actors pursue different objectives and face different constraints [29].

Based on system approach we tried to decompose the process of individual education route design into several key phases.

Decision making starts with a phase where people collect information. As a rule, a person collects information on programs, alternative education trajectories, job opportunities, employers, academic institutions, etc. from various sources. In the end of this phase the information, a person collected, get structured in a form of an informational field a person uses to make a decision.

Later on, he/she starts analyzing the information. In addition to information a person managed to collect, he/she evaluates some extra facts and conditions provided by the environment. These factors can be divided into outer and inner ones, where outer factors are market trends, economic situation in

a monotown, region, state, world, authorities' attitude or dominating policy in education and labour market, job opportunities, etc.; inner factors have close connection with a person, i.e. professional competences, personal qualities, marital status, family lifestyle and wellbeing, etc. As a result we have a list of conditions which are of this or that level of importance for people when they evaluate existing educational routes. Here, people apply their criteria to assess and range all possible alternatives to make final decision.

To manage individual education route means to monitor major criteria achievement (they can fit choice criteria). Assessment results can influence a decision to correct or change education route elements, i.e. courses or sets of courses, etc. Hence a new cycle of decision making starts [30].

Information model for individual education route design, developed to show how industry-university collaboration works to support monotown industries with advanced professionals, is depicted in Fig.1.

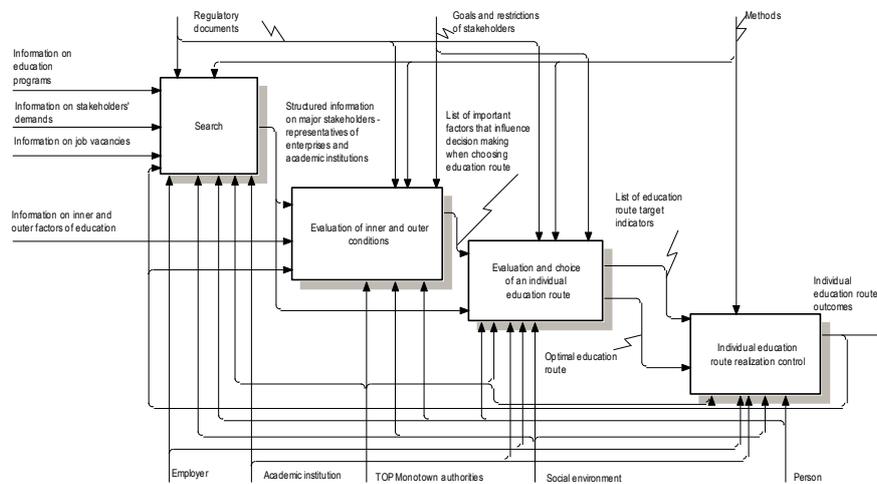


Figure 1. Individual education route design information model, based on industry-university collaboration, to support monotown industries with advanced professionals.

Table 1. An employer segment in an individual education route design information model

Stages	Employer - Source of Information (S)	Employer - Consumer of Information (C)
Search	Present day and future job vacancies; professional competencies in demand	Educational programs and graduates' competencies; CV; current or potential employees job expectations; a monotown development strategy
Analysis	Job description; results of graduates' on-the-job checks; educational programs relevance assessment	Education and labour markets trends; industries and businesses that already exist in a monotown, or new coming ones; stakeholders' estimation of job conditions
Evaluation and Choice	Competitiveness rate of educational programs and their graduates	Competitiveness of job vacancies; job placement choice criteria; program choice criteria
Monitor	On-the-job-training opportunities; job probation results; competencies relevance to potential job requirements	Programs outcomes; CV; on-the-job training courses marks

The informational model, depicted in Fig.1, decomposes the whole stream of information from and for all the stakeholders into several segments and stages, which comprise individual education route design. Basic stages employers follow in their search for qualified specialists and two roles employers perform (i.e. as sources of particular information other stakeholder search, and as consumers of information other stakeholder suggest), are exemplified in Table 1.

Same tables were created for all the stakeholders: TASED local authorities, residents, and institutions. These tables resulted into the informational stream within the system of teaching and training advanced professionals for monotown industries (the fragment is presented in Table 2).

Table 2. Informational stream within the system of teaching and training advanced professionals for monotown industries (fragment).

Type of Information	Residents	Employer	Academic Institution	TASED Local Authorities
Current and future job/work opportunities	C	S	C	C/S
Competency requirements	C	S/C	C/S	C/S
Educational programs	C	C/S	S	C/S
Graduates' competencies	C	C/S	S/C	C
Job requirements and conditions	S/C	S/C	C/S	C
Educational programs competitiveness	C/S	S	C	C
Competitiveness of job/work vacancies	S/C	C	C/S	C
TASED residents and employers	C	S	C/S	S/
Job/work placement choice criteria	S	C	C/S	C
Educational programs choice criteria	S	C/S	C	C

4. Conclusion

The problem of monotowns development in the sense of their economy diversification is increasingly important. It is in the centre of attention of federal, regional and local authorities, and it is in the interest of policy makers, educators and businesses, which exist or come to monotowns TASED that industry-university collaboration is developed. The advantages and potential opportunities of collaboration between stakeholders are argued neither by researchers nor by practioners. At the same time all stakeholders state that they fill lack of a unified decision support system that will contain information for and from all the stakeholders, and allow research, analyze and monitor situation in education and labour market.

The informational system for individual education route design, described in the paper helps formalize basic streams of information and their interrelations on all stages of decision making, and allows educators to derive education aims, goals and outcomes when they develop systems, approaches and programs to educate advanced professionals for monotown industries. The model also might be the ground for conceptual development of informational databases to support industry-university collaboration.

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References

- [1] Bogetic Z, Kleine A, Hernandez M, Luca O, Mirzoev A, Streifler S, Smits K, Titov S, Ulatov S 2009 Russian Economic Report World Bank in Russia **19** 13 figure 1.11 Homepage: <http://siteresources.worldbank.org/INTRUSSIANFEDERATION/Resources/305499-1245838520910/rer19-eng.pdf>
- [2] Clausen A 1984 The Pacific Asian countries : a force for growth in the global economy - address by A W Clausen, President, the World Bank and International Finance Corporation before the Los Angeles World Affairs Council (English) Presidential speech. Washington, DC: World Bank Homepage: <http://documents.worldbank.org/curated/en/428971468099589203/The-Pacific-Asian-countries-a-force-for-growth-in-the-global-economy-address-by-A-W-Clausen-President-the-World-Bank-and-International-Finance-Corporation-before-the-Los-Angeles-World-Affairs-Council>
- [3] Federal Law 473-FZ 29.12.2014 About Territories of advanced economic and social development in the Russian Federation Homepage: <http://kremlin.ru/acts/bank/39279>
- [4] Yablonskiy V 2008 Informational support for managing educational trajectories *Kreativnaya ekonomika* **12(24)** 58-61
- [5] Zakharova A, Lazareva A, Aleksandrov A 2016 Mathematical software for evaluating and supporting the selection decision on academic programs *Advances in Computer Science Research In: Proceedings of the 2016 conference on Information Technologies in Science, Management, Social Sphere and Medicine (ITSMSSM) vol 51* 554-559
- [6] Krylova N, Aleksandrova E 2002 How to provide individual education *Narodnoye obrazovaniye* **9** 73-82
- [7] Yang Y, Chuang Y, Huang C, Hou T and Yang C 2015 An efficient adaptive fuzzy learning diagnosis method for e-Learning *Journal of Internet Technology* **16(3)** 391-401
- [8] Ambrosevich M, Ayzenshtadt A, Nevzorov A 2007 Multi-criteria approach in education quality management: practices *Vyssheye obrazovaniye segodnya* **2** 62-64
- [9] Barkalov S, Belousov V 2006 How to choose adequate strategy to manage teaching at university *Vestnik Voronezhskogo gosudarstvennogo tekhnicheskogo universiteta* vol 2 **7** 677-71
- [10] Vroyeynstiyn A 2000 Higher education quality assessment. Recommendations on internal assessment in academic institutions of higher education *MNEPU (Moscow)*
- [11] Barani G, Azma F, Seyyedrezai S 2011 Quality indicators of hidden curriculum in centers of higher education In: *Procedia - Social and Behavioral Sciences* vol 30 1657-1661 DOI: 10.1016/j.sbspro.2011.10.321
- [12] Dyrenfurth M, Murphy M, Bertoline G 2010 Quality Indicators For Engineering & Technology Education In: Annual Conference & Exposition, Louisville, Kentucky Homepage: <https://peer.asee.org/16889>
- [13] Vershinin S 2004 Modernization of professional education NIRO (Moscow)
- [14] Ivashnova S 2015 The model of projection of a fuzzy individual professional educational trajectory *New Educational Review* vol 40(2) 69-80
- [15] Urintsov A, Dik V Individual learning trajectories as a key educational tool in the information society *Smart digital futures* vol 262 652-656
- [16] Mulkeen J, Abdou H, Leigh J, Ward P 2017 Degree and Higher Level Apprenticeships: an empirical investigation of stakeholder perceptions of challenges and opportunities. *Studies in higher education* vol 44 **2019** 333–346 DOI.10.1080/03075079.2017.1365357
- [17] Antcliff V, Baines, S, Gorb E 2016 Developing Your Own Graduate Employees: Employer Perspectives on the Value of a Degree Apprenticeship *Higher Education, Skills and Work-based Learning* 6(4) 378–83 DOI: 10.1108/HESWBL-05-2016-0032

- [18] Marhl M, Pausits A 2013 Third mission indicators for new ranking methodologies *Lifelong education: the XXI century* **1** 89-101 DOI: 10.15393/j5.art.2013.1949
- [19] Lysenko T, Tyrov I Design of basic educational programs with regard to the requirements of employers for the results of training in an automated information system Novye obrazovatel'nye tekhnologii Homepage, <http://aisroop.ru/notv-2013-proektirovanie-oop-s-rabotodatelnyami/>
- [20] Barnes T, Gibbons A 2002 Effective university-industry interaction: a multi-case evaluation of collaborative R&D projects *European Management Journal, Elsevier* vol 20(3) 272-285 DOI: 10.1016/s02632373(02)00044-0
- [21] Myoken Y 2013 The role of geographical proximity in university and industry collaboration: case study of Japanese companies in the UK *International Journal of Technology Transfer and Commercialisation (IJTTC)* vol 12 **1/2/3** 43-61 DOI:10.1504/IJTTC.2013.064170
- [22] Ankrah S, AL-Tabbaa O 2015 Universities-industry collaboration: a systematic review *Scandinavian Journal of Management* **31** 387-408 DOI:10.2139/ssrn.2596018
- [23] Chankseliani M, Relly S 2015 From the Provider-led to an Employer led System: Implications of Apprenticeship Reform on the Private Training Market *Journal of Vocational Education and Training* **67(4)** 515–28 DOI: 10.1080/13636820.2015.1076499
- [24] Dindire L, Asandei M, Ganescu C 2011 Enhancement of cooperation and communication between universities and the business environment, requirement for a functioning of the knowledge triangle: education, research, innovation *Theoretical and Applied Economics* vol XVIII **9(562)** 89-102
- [25] Kozlinska I 2012 Obstacles to university-industry cooperation in the domain of entrepreneurship *Journal of Business Management* **6** 153-160 Homepage:https://www.researchgate.net/publication/235339902_Obstacles_to_University-Industry_Cooperation_in_the_Domain_of_Entrepreneurship
- [26] Martin L, Lord G 2018 Warren-Smith I Juggling hats: academic roles, identity work and new degree apprenticeships *Studies in Higher Education* 0:0 1-14 DOI: 10.1080/03075079.2018.1550478
- [27] Minton A, Lowe J 2019 How are universities supporting employers to facilitate effective “on the job” learning for apprentices? *Higher Education, Skills and Work-Based Learning* **9(2)** 200-210 DOI: 10.1108/HESWBL-10-2018-0099
- [28] Durneva E 2013 How to integrate professional and educational standards Competence models of graduates: employers’ requirements *Mezhdunarodniy zhurnal eksperimentalnogo obrazovaniya* **8** 17-19
- [29] Rybnicek R, Königsgruber R 2019 What makes industry–university collaboration succeed? A systematic review of the literature *Journal of Business Economics Springer* vol 89(2) 221-255 DOI: 10.1007/s11573-018-0916-6
- [30] Zakharova A, Ostanin V, Teryoshkin S 2014 Regional informational decision support system to manage residents’ educational trajectories: structure and methods *Polzunovskiy vestnik* **2** 134-137