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Development of Engineering Students Competencies Based on Cognitive Technologies in Conditions of Industry 4.0

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Abstract: Industry 4.0 and Society 5.0 concepts are actively developing all over the world. The accelerating transition to Industry 4.0 and Society 5.0 sets new requirements for the university education system in qualifications and competencies of engineering universities graduates. The article reveals the possibilities of using cognitive models in the professional training of research engineers for new industries. Authors used the modeling method for creating a cognitive and metacognitive model of the process. It can be used for the development of forming the optimal structure of higher professional engineering education. The article substantiates that the main tasks of modernization of pedagogical approaches in modern education, is to establish the compliance of educational products with the labor market requirements and transform the structure of vocational education, providing training for professional specialists required by specific employers. Conclusions are drawn about the important role of soft skills for engineering education in Industry 4.0. The results obtained in the study can be used for the engineering category of students.

Keywords: Industry 4.0, engineering education, cognitive abilities, metacognitive competencies, reflection, individual's self-development.

Introduction

The 21st century has fundamentally changed the traditional models of learning, communication, and work in Engineering Science, due to the development of modern concepts of Industry 4.0 (Oztemel and Gursev, 2020) and Society 5.0 (Onday, 2019). New industries of these concepts need new competencies from engineers (Subheesh and Sethy, 2020).

Due to the framework of Industry 4.0 and Society 5.0, industries and enterprises are developing when their activities are largely based on research and innovation, as well as a project-based approach to the implementation of search and innovation activities. Industries such as aircraft and automobile manufacturing, chemical and pharmaceutical industries, production of new composite materials, and a number of others, work on the basis of the project and "they are all notable for technological developments that have changed the way we live and work "(Dinsmore and PMP, 2014). The development of cognitive abilities starts to be one of the first criteria for engineering education (Peng and Kievit, 2020).

At the same time, project work requires special qualifications and special competencies of specialists involved in projects (Mingaleva, 2018). Also it should be noted that the term "cognitive engineer" appeared in modern Russian scientific and managerial science several years ago (Sheketa, Bestylny and Khrabatyn, 2006).

The concept of Society 5.0 is considered as one of the models of sustainable development. The main idea of the concepts of Industry 5.0 and Society 5.0 is the following: digital technologies for the development of society. The fourth industrial revolution and the concept of Industry 4.0 "should not consider promising technologies as simple tools that are completely under our conscious control.... Instead, we should try to understand how and where human values are embedded in new technologies and how technologies can be applied for the common good, environmental protection and human rights" (Schwab and Davis, 2018). Considering the increasing importance of sustainability and the role of engineers in society: "the key criteria that should be considered in models to evaluate the insertion level of sustainability into engineering education" (Rampasso et al., 2020). Generally the role of human resources on the economy is significant as it is presented in case study of Balkan EU member states Vukovic et al.

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(2015) and it is the same for all world.

Also many scientists pointed that role of university in transformation to Industry 5.0 and Society 5.0 is very important, Kochetkov, Larionova, and Vukovic, (2017) noticed in their paper that: "..historically, it is possible to allocate four types of the university by analogy to four industrial revolutions. In the conditions of the fourth industrial revolution, there is a radical shift in the university model. From research and development and technology transfer, the university moves to the creation of the intellectual capital". Their proved this by case studies of the most successful Russian technological entrepreneurs university, Novosibirsk and Tomsk universities.

So obtaining new competencies is possible both in the process of professional activity and at the stage of studying at university. However, in this case, the use of the old "classical" methods and teaching models is no longer suitable. The main emphasis in the requirements of employers in modern industries is increasingly placed on the formation of cognitive skills and cognitive competencies in future specialists. This, in turn, presupposes a wider application of various cognitive educational models in the process of teaching and training specialists. The wider application of cognitive models in education is also facilitated by the digitalization of all aspects of society (Siarova, Sternadel, and Mašidlauskaitė, 2017), which provides students and teachers with effective tools for monitoring and checking the process of students' intellectual activity. In this regard, research and generalization of positive practical experience in the application of cognitive models in education in Russia and abroad is highly relevant.

Literacy discussion

Turning to the history of the application of various educational models and approaches in the higher education system, we note that in this study, under the term cognition (lat. "cognitio", cognition, study, awareness) we mean the ability to learn, and under cognitive technologies - ways and algorithms for achieving the goals of subjects, based on the processes of cognition, learning, and information processing.

A cognitive model, in a broad sense, "can be considered as an interpretive information structure intended for cognitive analysis and especially effective for analyzing complex or unstructured information" (Tsvetkov, 2016). A cognitive model in education is a structured description of the process of achieving a result (forming the necessary competencies) based on the use of cognitive technologies and the development of cognitive abilities (Matsuo and Tsukube, 2020). A similar approach is followed in the research of Bogavac and Đukić, 2017; Cosgrove and O'Reilly, 2020; Laguador and Dotong, 2014 and Patil and Codner, 2007.

One feature of learning based on the use of cognitive technologies is the emphasis on the development of creative abilities. However, with this approach, the differences between people in mental and creative abilities naturally appear. This leads to the fact that intellectual inequality is clearly manifested among students, which leads to a complication of the communication process within student groups. In addition, when training is focused on the development of creative abilities, it is difficult to find a single criterion for assessing such training. This, as well as a number of other features of cognitive learning, contributed to the fact that, until recently, this approach has been applied in higher education systems to a rather limited extent.

Earlier we built a 5-component model of modern specialists' competence (Figure 1). As it was proved earlier, the most difficult to assess are the competences from the group of cognitive (cognitive) competences.

These competences are closely related to such notions as "intellect" and "cognition". Cognition is a general term applied to any process, basic structure, procedure, action, which allows a person to know and be aware of the environment, the tasks ahead of him/her and the ways to solve them (a way out of a difficult situation). Intellect is a hypothetical construct underlying a person's ability to cope with abstractions, learning and effective behavior in new situations (the ability to judge, understand and reason). Collectively, cognitive competences include actions such as perception, learning, memorizing, reasoning, thinking, speaking, and evaluation.

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An important methodological peculiarity of building a cognitive model of learning and formation of modern competencies is the need to identify, account for and reflect the interrelationships between competencies from all groups. The analysis has shown that the majority of competencies from the group of cognitive competencies complements and enhances the competencies from other groups, as well as experiences their impact. In particular, such element of cognitive competencies as "ability to discover" is closely related to such metacompetencies as "self-development" and "creativity". This includes "skills/ skills", which in most models is understood in a narrower context as the ability to perform complex motor and/or cognitive actions with ease, accuracy, and adaptability to changing conditions or in a broader context all acquired abilities.

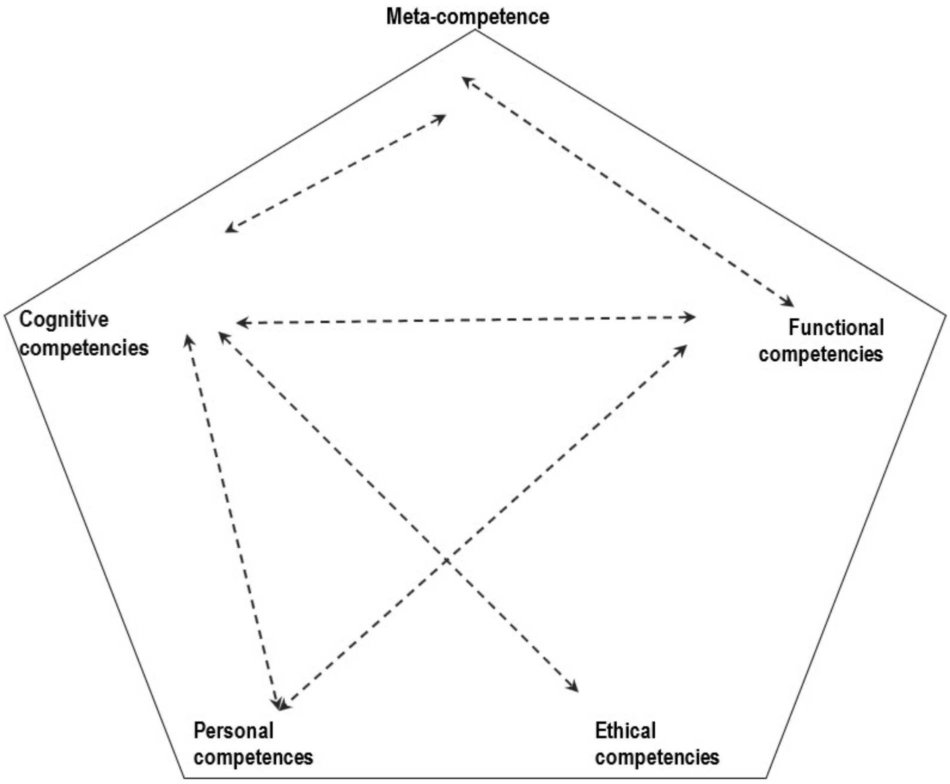

Figure 1. Model of 5-component specialist competency

There is also a very interconnection between groups of functional and cognitive competencies, especially those specialists who are engaged in scientific research, development, search for new materials, products, methods of their production (design engineers, employees of research laboratories of enterprises, etc.). In particular, many studies emphasize that the cognitive ability of individuals and/or members of social groups to learn (knowledge, skills, etc.) that they acquire, in turn, should be used to solve complex problems, i.e., ensure the implementation of functional competencies (Mingaleva, 2018) . Mental and psychomotor competencies from the group of functional competencies are closely related to individual competencies, while social competencies are closely related to indicative notions, skills and abilities, as well as theoretical knowledge that allow employees to understand their place and role in society, responsibility to society as a whole, the need to comply with social standards and rules of responsible behavior, including the development of new products and materials.

Competencies necessary for future cognitive engineers are formed in the process of training through the use of new pedagogical methods and tools, including the use of cognitive technologies. The study of modern educational practice has shown that nowadays cognitive models (Figure 1) and technologies are applied mainly in three directions of educational activity:

- in the process of full-time education (classical or project-based),
- in the process of distance education,
- in the process of testing.

Each of the selected areas is characterized by its own technologies and end results. In the framework of previous studies, it was noted that the method of "competency interview", applied in personnel management, was tested during testing of students in terms of determining their cognitive abilities. This method allows students to evaluate cognitive actions such as reasoning, thinking, speech, and evaluation, as well as cognitive ability to find a solution, which are manifested by students in the course of solving a problem academic situation.

Based on a study of scientific literature and the practice of using cognitive models in education, we identified the following differences in approaches to organizing the educational process based on the classical approach and the cognitive approach. The results are shown in Table 1.

Table 1
Comparative analysis of classical learning and cognitive learning

Learning element	Classical learning	Cognitive learning
Final goal	Formation of formalized and personal knowledge	Development of creative abilities
Control	Checking the result	Checking the process of obtaining the result
Criteria for assessing learning outcomes	The same for all	Individual, based on mental and cognitive abilities
Peculiarities of the interpretation of criteria	Obtaining the highest score in the framework of the point grading system к	Manifestation of a non-standard approach to solving the problem
Learning tools	Traditional lectures, workshops, laboratory work	Cognitive graphics based on modern ICT (Vlasov, Juravleva, Shakhnov, 2019)
The optimal group size for training	20-30 students	5-7 students

As it is presented in Table 1, the educational approach based on the use of cognitive technologies differs significantly from the traditional approach, even if the latter widely uses ICT, virtual learning, distance learning and other modern technologies.

Changing the requirements for the qualification characteristics of specialists in the direction of expanding intellectual and communication competencies naturally presupposes a transition to cognitive learning models, and the widespread use of digital technologies makes it possible to reduce differences in students' cognitive abilities.

We investigated the possibility of using cognitive models in the training of students of engineering specialties (chemical-technological and aerospace faculties), focused on research and design work in the framework of progressive directions of creating new structural materials and products from them.

Engineering education is under strong pressure from manufacturing to transition to Industry 4.0 (Kiel et al., 2017). Also on the way to sustainable development, cognitive technologies have an important role in engineering education (Potočan, Mulej and Nedelko, 2020). Table 2 is presenting groups of criteria for the evaluation of engineering education for sustainable development (EESD) (Rampasso et al., 2020).

Grouping results of criteria for evaluating engineering education for sustainable development (EESD) from Table 2 could be presented like it is in Figure 2, by blocks. The same vision is proved in researches of Yakymchuk et al., 2020.

Table 2
Criteria for the evaluation of engineering university education for sustainable development (EESD)

№	Group of criterion	Criteria to evaluate engineering education for sustainable development (EESD) (Rampasso et al., 2020)
1	Courses Content	C1 Use of transdisciplinarity in teaching C13 Availability of adequate and constantly updated teaching material to include sustainability in the course C14 Proper training of professors to insert sustainability into their disciplines
2	Teaching Methods	C6 Development of critical thinking in students throughout the course C7 Development of holistic and systemic thinking in students throughout the course to enable them to make decisions responsibly C9 Use of active learning approaches to problem solving to teach aspects related to sustainability
3	Networking	C2 Establishment of global partnerships C4 Encouraging students to volunteer through extracurricular activities C8 Discussion of issues related to values and ethics with students throughout the course C10 Use of service-learning towards the local community for educational purposes C11 Constant discussion, throughout the course, about industrial applications of technical knowledge for sustainability (for example, life cycle assessment, cleaner production, ecologically efficient strategies for resources use, etc. C12 Development of communication skills in students to enable them to work within multidisciplinary groups
4	University Infrastructure	C3 Alignment between sustainability insertion and institutional strategy, with top management support for needed adjustments C5 Balanced focus among environmental, social, and economic aspects of sustainability C15 Use of sustainability concepts in university installations

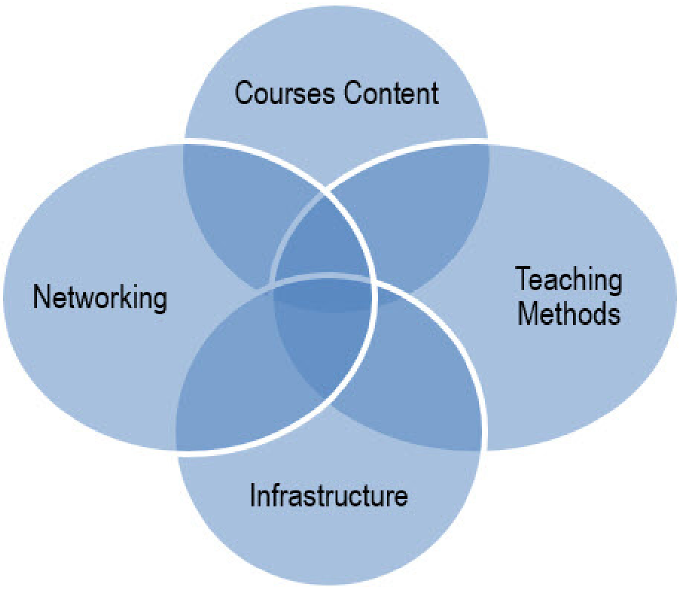

Figure 2. Main group of tools for cognitive engineering education

Due to analyses of modern researches, which are presented bellow we formulate 2 hypothesis about modern engineering education and cognitive approach in it.

Hypothesis 1.
The modern system of engineering education in Russia is not yet fully capable of forming the entire set of cognitive competencies required by modern cognitive engineers.

Hypothesis 2.

To form the necessary set of cognitive competencies, it is necessary to use cognitive learning technologies based on the creation of cognitive learning models.

For testing Hypothesis 1 and Hypothesis 2 we implemented survey in Perm National Research Polytechnic University in September 2020.

Materials and Methods

Sample description

The empirical study involved 263 volunteers – students of 4nd-5th years of study, and master's programs (5th-6th years of study) in the engineering specialties (chemistry and mashing building), balanced distribution by gender (41.2% of women, 58.8% of men). Senior students (4-5) were not randomly selected. On the 3rd year students of engineering specialties undergo practical training, and many starts working at enterprises. At this time students already get the first idea about the place of future work, about features and character of work, functional responsibilities, specific scientific and research activities. This allows senior students to more clearly and consciously define the competencies and skills they will need in their future work. This also applies to cognitive competencies.

Data collection methodology

The study was held in September 2020. Despite the scientific urgency and practical relevance of the topic, there are still no reliable diagnostic methods for diagnosing cognitive competencies.

There are some modern researches in the same fields. Assessment of programme outcomes through exit surveys of Engineering students was implemented previously by many scientists (Othman et al., 2011).

The results of our previous research «The practice of using digital technologies of practice-oriented educational technologies in Perm National Research Polytechnic University (PNRPU)» were also used for design of the content of the research survey Mingaleva (2018).

We also implemented short survey of students of engineering universities. A survey of the quality of cognitive skills and competencies was conducted among 4-5 year students. For this purpose, a list of cognitive competencies was compiled, which includes: list of competencies from groups "Cognitive strategies" and "Cognitive abilities", developed by proposed ones Robinson et al., 2005. This is the sum of main cognitive competences: «Judges importance" (Q1), «Analyses tasks»(Q2), «Identifies factors», «Learns from mistakes», «Seeks simplest solutions», « Makes effective decisions», «Thinks intuitively»(Q3), «Thinks 'outside the box»(Q4), « Is able to learn»(Q5), «Thinks quickly»(Q6). The results of our previous research «The practice of using digital technologies of practice-oriented educational technologies in Perm National Research Polytechnic University (PNRPU)» were also used for design of the content of the research survey.

In total, students were offered a list of 10 competencies (Robinson et al., 2005), closely correlated with content of Table 2. In the course of the survey, students were asked the following questions characterizing their specific cognitive competencies:

1. Which of the following competencies were formed in your previous training in the basic program?
2. Which of the competences listed below were formed in your self-study process?
3. Which of the competences listed below have been formed in the course of your internship and work at the enterprise?
4. Which of the competences listed below will you need for your future work?
5. Which of the following competencies do you need to develop during your remaining time at the university?

Results

By answering these questions, students were able to choose several competencies. In answering these questions, students expressed their personal subjective opinion about the existence of specific competencies and the need for such competencies for their work. The results of questionnaires processing are presented in Table 3. The matrix cells present the total number of positive answers with regard to each of the listed competences.

Table 3
Survey Results, number of positive answers

N	Survey questions	Competences									
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	Which of the following competencies were formed in your previous training in the basic program?	201	167	207	115	15	58	46	15	37	15
2	Which of the competences listed below were formed in your self-study process?	153	174	216	212	24	19	26	37	9	198
3	Which of the competences listed below have been formed in the course of your internship and work at the enterprise?	182	196	241	237	36	16	31	42	11	162
4	Which of the competences listed below will you need for your future work?	210	202	253	241	231	206	212	252	181	235
5	Which of the following competencies do you need to develop during your remaining time at the university?	254	198	175	198	18	41	37	28	12	174

Table 3 presents that among 10 main cognitive competences: «Judges importance” (Q1), «Analyses tasks»(Q2), «Identifies factors»(Q3), «Learns from mistakes»(Q4), «Seeks simplest solutions»(Q5), «Makes effective decisions»(Q6), «Thinks intuitively»(Q7), «Thinks ‘outside the box»(Q8), «Is able to learn»(Q9), «Thinks quickly»(Q10) the most important by students opinion are Q1,Q2 and Q3.

Table 4
Survey Results, % of positive answers

N	Survey questions	Competences									
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	Which of the following competencies were formed in your previous training in the basic program?	76,4	63,5	78,7	43,7	5,7	22,1	17,5	5,7	14,1	5,7
2	Which of the competences listed below were formed in your self-study process?	58,2	66,2	82,1	80,6	9,1	7,2	9,9	14,1	3,4	75,3
3	Which of the competences listed below have been formed in the course of your internship and work at the enterprise?	69,2	74,5	91,6	90,1	13,7	6,1	11,8	16,0	4,2	61,6
4	Which of the competences listed below will you need for your future work?	79,8	76,8	96,2	91,6	87,8	78,3	80,6	95,8	68,8	89,4
5	Which of the following competencies do you need to develop during your remaining time at the university?	96,6	75,3	66,5	75,3	6,8	15,6	14,1	10,6	4,6	66,2

In the course of the research it was established that in Russian universities a part of cognitive competence is formed and fixed in the skills of students already in the first years of study. These are such competences as the ability to assess the importance of a problem (Q1) or a task, the ability to analyze tasks (Q2), the ability to determine the factors (Q3) affecting the situation, problem, task. The presence of these competences in general was pointed out by the interviewed students.

Discussion

The current requirements of Industry 4.0 require employees to have new skills, knowledge and competencies focused on the SDG. This requires the expansion of cognitive competencies of university graduates.

The cognitive strategy revealed by the survey results is called by its content as "Looking for the simplest solutions" (Q5) is very attractive for students in their future work (87.8% of positive answers to question 4), but in the process of learning it is not formed fully enough (5.1% of positive answers to question 1).

There is the similar situation with cognitive ability assessment "Makes effective decisions" (Q6). According to respondents, this cognitive ability is needed in future work (78.3% of respondents answered 4 questions positively), but is not fully developed in the learning process (22.1% of respondents answered 1 question positively).

Competences such as "Thinks outside the box" (Q8), and "Thinks fast" (Q10) are very attractive to students (95.8% and 89.4%), but most of them have not formed with any form of training (face-to-face, on their own, in the process of industrial practice.

Such cognitive ability as "Intuitive Thinking" (Q7), according to the majority of respondents, is poorly developed (17.5%), although in terms of the success of future work, especially its scientific and research part of design engineers, this ability is of great importance (80.6% of positive answers to question 4). Only a very small number of students consider this competence to be innate and undeveloped.

At the same time, the cognitive ability "Knows how to learn" (Q9) and the cognitive strategy "Learns from mistakes" (Q4) are considered by many students to be developable. Moreover, quite a few students (80.6% of the total number of students enrolled) noted that they were able to develop these competencies independently through self-learning.

Conclusions

It is obvious that classical education is not enough for transition to Industry 4.0 and it is very important to have soft skills for career success. Modern trends of Industry 4.0 need workers to acquire new skills, knowledge, and competencies, focused on the SDGs. This implies the expansion of the cognitive competencies of university graduates.

Implementing cognitive education in engineering education meets a lot of different challenges (Rajaee et al., 2013) like not standard business situations, international multi-linguistic team and etc. In the course of the study, it was found that in Russian universities, part of the cognitive competencies are formed and consolidated in the skills of students already, and are formed in the first years of study. Also, some of the competencies are developed during the process of self-training and in the course of industrial practice within a business. At the same time, modern students expect more progression from the education system, to develop cognitive competencies among specialists and engineers, which will allow them, in the future, to more effectively carry out scientific research (experimental), generate ideas, find solutions faster, and work more effectively in a team. Students expect new teaching methods from universities and are eager to accept them.

Especially important for students of engineering specialties, are such cognitive abilities and cognitive strategies "not received" in the learning process, such as the ability to find the simplest solutions, the ability to make effective decisions, the ability to think outside the box, and to think quickly.

An education system that meets the requirements of the market must develop and introduce pedagogical methods into the educational process that allow for the comprehensive development of the professional competencies necessary for cognitive engineers. Future research will focus on the development and adaptation of such progressive pedagogical methodologies to suit different engineering specialties.

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Conflict of interests

The authors declare no conflict of interest.

References

Bogavac, D., & Đukić, T. M. (2017). Non-formal education within the function of responsible parenting. *International Journal of Cognitive Research in Science, Engineering and Education, 5*(1), 31. https://doi:10.5937/IJCRSEE1701031B

Cosgrove, T., & O'Reilly, J. (2020). Theory, practice and interiority: an extended epistemology for engineering education. *European Journal of Engineering Education, 45*(1), 38-54. https://doi.org/10.1080/03043797.2018.1544226

Dinsmore, P. C., & PMP, D. (2014). Team Building and Interpersonal Skills for Dynamic Times. *The AMA Handbook of Project Management.* Retrieved from http://dl.booktolearn.com/ebooks2/management/9780814433393_the_ama_handbook_of_project_management_8c7c.pdf#page=424

Kiel, D., Müller, J. M., Arnold, C., & Voigt, K. I. (2017). Sustainable industrial value creation: Benefits and challenges of industry 4.0. *International Journal of Innovation Management, 21*(08), 1740015. https:doi.org/10.1142/S1363919617400151

Kochetkov, D. M., Larionova, V. A., & Vukovic, D. B. (2017). Entrepreneurial capacity of universities and its impact on regional economic growth. *Economy of Region/Ekonomika Regiona,* (2). 477-488. https:doi.org/10.17059/2017-2-13

Laguador, J. M., & Dotong, C. I. (2014). Knowledge versus practice on the outcomes-based education implementation of the engineering faculty members in LPU. *International Journal of Academic Research in Progressive Education and Development, 3*(1), 63-74. http://dx.doi.org/10.6007/IJARPED/v3-i1/640

Matsuo, M., & Tsukube, T. (2020). A review on cognitive apprenticeship in educational research: Application for management education. *The International Journal of Management Education, 18*(3), 100417. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S1472811720301841

Mingaleva, Z. (2018). Peculiarities of the formation of communication competences within the framework of project training in a polytechnic university. *Rhetoric and Communications E-journal, 36*, Retrieved from http://journal.rhetoric.bg/?p=2141

Onday, O. (2019). Japan's society 5.0: Going beyond Industry 4.0. *Business and Economics Journal, 10*(2), 1-6. https://10.4172/2151-6219.1000389

Othman, N. T. A., Misnon, R., Abdullah, S. R. S., Kofli, N. T., Kamarudin, S. K., & Mohamad, A. B. (2011). Assessment of programme outcomes through exit survey of Chemical/Biochemical Engineering students. *Procedia-Social and Behavioral Sciences, 18*, 39-48. http://dx.doi.org/10.1016/j.sbspro.2011.05.007

Oztemel, E., & Gursev, S. (2020). Literature review of Industry 4.0 and related technologies. *Journal of Intelligent Manufacturing, 31*(1), 127-182. https://10.1007/s10845-018-1433-8

Patil, A., & Codner, G. (2007). Accreditation of engineering education: review, observations and proposal for global accreditation. *European journal of engineering education, 32*(6), 639-651. http://dx.doi.org/10.1080/03043790701520594

Peng, P., & Kievit, R. A. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives, 14*(1), 15-20. https://doi.org/10.1111/cdep.12352

Potočan, V., Mulej, M., & Nedelko, Z. (2020). Society 5.0: balancing of Industry 4.0, economic advancement and social problems. Kybernetes. Retrieved from https://www.emerald.com/insight/content/doi/10.1108/K-12-2019-0858/full/html

Rajaee, N., Junaidi, E., Taib, S. N. L., Salleh, S. F., & Munot, M. A. (2013). Issues and challenges in implementing outcome based education in engineering education. International Journal for Innovation Education and Research, 1(4), 1-9. http://ir.unimas.my/id/eprint/1168

Rampasso, I. S., Quelhas, O. L., Anholon, R., Pereira, M. B., Miranda, J. D., & Alvarenga, W. S. (2020). Engineering Education for Sustainable Development: Evaluation Criteria for Brazilian Context. *Sustainability, 12*(10), 3947. https://doi.org/10.3390/su12103947

Robinson, M. A., Sparrow, P. R., Clegg, C., & Birdi, K. (2005). Design engineering competencies: future requirements and predicted changes in the forthcoming decade. *Design Studies, 26*(2), 123-153. http://dx.doi:10.1016/j.destud.2004.09.004

Schwab, K., & Davis, N. (2018). *Shaping the future of the fourth industrial revolution.* Currency. Retrieved from https://dl.acm.org/doi/book/10.5555/3312394

Sheketa, V., Bestylny, M., & Khrabatyn, R. (2006, February). Applicable scaling of user predicate queries in given categorical strategy and restrictions system. In *2006 International Conference-Modern Problems of Radio Engineering, Telecommunications, and Computer Science* (pp. 34-37). IEEE. Retrieved from https://ieeexplore.ieee.org/document/4404436

Siarova, H., Sternadel, D., & Mašidlauskaitė, R. (2017). Assessment practices for 21st century learning: review of evidence. *NESET II report.* https://doi.org/10.2766/71491

Subheesh, N. P., & Sethy, S. S. (2020). Learning through assessment and feedback practices: A critical review of engineering education settings. *EURASIA Journal of Mathematics, Science and Technology Education, 16*(3), em1829. https://doi.org/10.29333/ejmste/114157

Tsvetkov V.Ya.(2016). Cognitive model stratification. *International Journal of Applied and Basic Research. 2*(1). 136. http://www.applied-research.ru/pdf/2016/2-1/8456.pdf

Vlasov, A. I., Juravleva, L. V., & Shakhnov, V. A. (2019). Visual environment of cognitive graphics for end-to-end engineering project-based education. *Journal of Applied Engineering Science, 17*(1), 99-106. https://doi.org/10.5937/jaes17-20262

Vuković, D. B., Shpak, N. A., Radovanović, M. M., Portugal Duarte, A., & Radulović, D. (2015). The role of human resources on the economy: a study of the balkan eu member states. J*ournal of the Geographical Institute'Jovan Cvijic'SASA, 65*(2). https://doi.org/10.2298/IJGI1502123V

Yakymchuk, B. A., Chystiak, O. V., Padalka, R. G., Moskalyk, H. F., & Denha, N. M. (2020). Fostering Cognitive and Creative Thinking Styles Using Educational Tools Aimed at the "Creative Economy" Model in the Process of Vocational Education and Training. Psychology and education, 57(1), 01-07. Retrieved from http://www.psychologyandeducation.net/Article/fostering-cognitive-and-creative-thinking-styles-using-educational-tools-aimed-at-the-creative-economy-model-in-the-process-of-vocational-education-and-training.pdf