The trend of higher engineering education towards achieving technological development

V Garbuz and P Topala
“Alecu Russo” Balti State University, Faculty of Real, Economical and Environmental Sciences, Pushkin Str. 38, 3100, Balti, Republic of Moldova

E-mail: garbuz_veronica@yahoo.com

Abstract. The technical-scientific progress, rapidly evolving technologies, developing of innovative processes in the sphere of production, the effect of the economy globalization, etc. require a rethinking and complete reformatting of the education system in general and particularly, of that one related to engineering. This paper analyses development trends of higher technical education in the world and particularly in the Republic of Moldova. It is analysed the dynamic evolution of the number of students and graduates ethnic domain specifically for Moldova in order to elucidate this issue. There were realised three studies attended by students from engineering specialties, young engineering specialists and their employers. Research results highlight the key role of knowledge and skills that young professionals must possess to achieve technical performance, scientific and economic information in accordance with international standards. With an accelerated technological progress, it is clear that we are on the top of a new era of machine learning, machine doing and finally, of a true artificial intelligence (AI). It is a central point in history that presents both opportunities and challenges. And undoubtedly, the most significant social and economic impact will be on the job - it is required to determine what work will be performed and by whom. In this aspect, application of exponential technologies is analysed in order to strengthen labor and accelerate business growth, as we enter the Fourth Industrial Revolution. In this new era, the transition to innovations based on combinations of technologies, force companies to reconsider how they do business, including requirements put forward in preparing new specialists in the labor market. Their actions should be oriented in training a generation of self-motivated and responsible engineers of the highest quality, able to participate in solving societal and engineering challenges of the XXI century through creative and viable solutions.

1. Introduction
The accelerated technological revolution owns for the 21st century created premises for irreversible changes in technique and technology, with new approaches and applications, where engineering expertise is made available to society. Main innovations including sensor technology, artificial intelligence, robotics, nanotechnology, and bioengineering converge due to hyper-connected digital world.

The business world and the entire global economy will change a lot from the way we know them today, as a result these technological innovations. Significant results in scientific discovery and innovation in many areas will be recorded during the next decades. Technology, activity field of engineers and engineering scientists is an essential component in achieving these innovations. In some decades, today's graduates of engineering specialties will be mid-career professionals and will act as integrators and innovators in the public, private and academic sectors.
They should also be able to influence colleagues, customers and business managers and develop an entrepreneurial attitude throughout their work. But to achieve such a development level, the actual engineering high education needs to form and develop its students’ creative and innovative skills, generate "out of the box" situations, encourage divergent thinking, generate opinions and subjective interpretations. These ingredients will have to complement and partially replace styles and skills traditionally associated with engineering, as abstract thinking and concrete answers are. Higher education must be approached as a fundamental element alongside technical research, or engineering is a social practice of conceiving, designing, implementing, producing and supporting complex technological products, processes or systems. The emergent behaviour development of humanity makes societal challenges and engineering difficult to unlock with old methods and tools. Uncertainty and delay are mostly caused by the unfinished entry of new information that requires the engineer to adapt constantly his behaviour and action strategies. This is especially true when human behaviour, interpretations and decisions play a key role in solving the problem. In order to reduce uncertainty, solutions that have been tried and tested in the past are often used, such as problem approaching by each individual individual (researcher). Thus, skills of tomorrow's engineer must clearly overcome the technical field.

The first challenge in education has always been to anticipate skills that graduates will need in their future jobs. To do this, higher education institutions around the world need to create specialists for jobs that do not yet exist, using technologies that have not yet been invented, to solve problems that have not yet been identified. What we know is that tomorrow’s world will be an intense VUCA (volatile, uncertain, complex, ambiguous), digital and hyper-connected. Although great progresses are unpredictable, future scenarios are uncertain, we can be sure that engineers will be better when they master engineering methods and tools, a set of common engineering languages such as mathematics, algorithmic thinking, systems thinking, thinking collaborative design, ethics and visual literacy, 3D spatial design, reading of charts and diagrams, using of mental maps). Most importantly, engineers must learn to use their imagination and have agile and resilient skills to address the technical field.

2. Engineering education graduates’ number and quality

The most visible and highly issue facing the engineering profession is not reaching existing jobs with graduates of engineering specialties, that becomes less every year.

According to research conducted by the World Economic Forum (which excludes China and India due to lack of data), Russia leads the way, producing an annual total of 454,000 graduates in engineering, manufacturing and construction, [2]. The United States is in second position with
237,826 while Iran rounds off the top three with 233,695. Developing economies including Indonesia and Vietnam have also made it into the top 10, producing 140,000 and 100,000 engineering graduates each year respectively (figure 1).

As it is seen in figure 1: countries from EU are almost missing in the world rankings, exception is France, that had about 105,000 graduates of engineering specialties.

A significant issue is the capacity of developed countries to solve their professional engineering staff shortage by attracting well educated engineers from developing countries by offering interesting employment with attractive salaries, [3]. These graduates have often have been educated in that developed country and are especially attractive employees sought by international companies. However, their benefit occurs at the expense of the developing countries that urgently need to enhance their engineering capabilities. This raises difficult ethical issues that are usually ignored. Australia is an example of a country where this occurs. A recent report concludes that the current annual number of engineering graduates from its universities meets approximately half of that country’s employment requirement, [4]. The balance of the annual recruitment is met from the employment of international students who have studied in the country and by the employment of engineers who are attracted from other countries.

There are some industrial sectors where the loss of European expertise is more problematic than in other ones. Of course, Europe needs the information and communication technology sector to be competitive in sectors like automotive, industrial engineering and others.

The AT Kearney report, based on industry data and interviews with executives and researchers, suggests that Europe is losing ground due to such factors as shortage of skilled engineers, market fragmentation or lack of a strategic vision, [5-7].

According to the European Commission, Europe invests in research and development fields with the equivalent of almost 1% of GDP less than the US and the equivalent of 1.5% of GDP less than China and Taiwan.

Although, the largest hi-tech companies in Europe are investing in Research and Development (R&D), the investment volume exceeded that of some Asian and US companies. Last year, the South Korean company Samsung invested more than 6% of its revenue in R&D, or 13 billion $ a year, and allocated 65,000 employees for these activities. Although the European Commission has officially recognized the importance of technology for growth, Europe's competitiveness and the management of potential social problems, decision-makers have not adopted enough steps to stop the decline hi-tech sector in Europe. The study's authors argue that the European Union lacks a supreme strategic plan, although the European Commission plans to invest around 70 billion euros in technology-based sectors in the next seven years through the strategy "Horizon 2020 ".

In Romania, yearly, the number of graduates of engineering specialties is about 30 thousand, or 22% from the total university graduates, in comparison with 70% of engineers in 1990 of total university graduates, according to data from the Department of Statistics. It is clear that engineers are very searched. Major industry investments, especially from automotive one, have made that engineers are in a high demand and led to partnerships between companies and universities, because young people should be specialized in modern technologies or workflows.

In Moldova, the number of engineering graduates is very modest, 5399 persons for Cycle I License and 349 for Cycle II Master in 2018.

Nationally, the number of high education graduates decreased by 11% for cycle I and by 6% for cycle II.

In 2018, the share of engineering graduates from the total number of graduates was 8.4% for cycle I and 6.5% for cycle II in 2018. While engineering graduates’ deficit is a problem for most countries, an issue closely related to the number of engineers is the inadequate quality of their professional training. Although it is expected that graduates of engineering programs possess different skills and attributes, many of them are unable to carry out engineering activities that should be performed by a graduate engineer.
There are several reasons related to, where it is to be mentioned:
- deficient curriculum;
- inappropriate development of graduates' personal abilities;
- academic staff with insufficient practical experience in the field of engineering;
- overloaded staff and/or unclear instructions for students
- inadequate facilities (lack of laboratories and appropriate research facilities);
- insufficient financial resources.

3. Research methodology

In order to identify the differences between employers 'and students' expectations in hiring, we used as a research tool the questionnaire as it allows for a quick collection of information, allowing the extrapolation of the results obtained by researching a sample to the entire population (with a margin of error), obtaining a certain "profile" of it.

Three distinct instruments were developed and applied to analyse the situation engineering graduates' specialties in Moldova: a) questionnaire for students in the last year of study (210 respondents); b) questionnaire for employers (8 respondents); c) questionnaire for young specialists (153 respondents). The study was attended by students and graduates of the following high education institutions: Technical University of Moldova (UTM), Moldova State University (USM), State Agrarian University of Moldova (UASM), State University "Alecu Russo" Balti (USARB), [9]. The interview guide for employers was built and used as a basis for recording employers' expectations for future engineers.

4. Results of the research

In Studying of the three respondents' categories allowed the multidimensional analysis of the situation of young engineers on the labor market.

4.1. Questionnaire „graduates and labor market”

When asked "where they want to work after graduation: at home or abroad?", 53% of respondents opted for a job in the country and 36% - for a job abroad. The gender analysis of the preference to stay at home or look for a job abroad, the following situation reveals: 58% of youth men and 55% of young women are ready to work in Moldova, while 41% of men and 39% of women are ready to go abroad in search of a job.
Students from the engineering have chosen this field of study, because they have interest and predisposition to Science, Technology, Engineering and Mathematics (STEM) (66%); engineering professions are well paid (35%).

Youths’ continuing education and training extends to areas that contribute to the formation and development of skills and competences to facilitate / accelerate finding a job and the successful development of professional activity. The young people mentioned several disciplines that suggest to be included in the curricula of different faculties and specialties as: foreign languages (28.62%), psychology (8.81%), critical thinking, time management, technical drawing, and so on.

In conditions when it is more difficult to find a job, self-employment is an alternative, that is, practice of entrepreneurship. Thus, each second graduate (49.21%) believes that the course "Business Initiation" in the university curricula is imperative and necessary because it will increase young specialist' employability.

Young people's expectations towards the future employer relate to the financial component, but also to the psychological comfort at the workplace, recognition and valorisation of the skills developed within the higher education system.

4.2. Questionnaire „young professionals in employers’ view”

Links with educational institutions are consolidated at 88% of the surveyed companies. These ones are exploited in multiple forms: student practice; recruitment; participation in the exam / assessments; curriculum development; continuous training [10]. Significantly, many employers have close links with engineering departments to interact with students and directly to participate in their personal and professional formation.

Often, when recruiting staff, employers rely on individual applications (52.27%) or on persons registered in the Territorial Agencies for Employment (40.91%). Employers use multiple recruitment methods and channels simultaneously to increase the efficiency of recruiting and selecting the most suitable employees.

Most employers (86%) expressed satisfaction with of young people’s theoretical knowledge in employment. This knowledge is demonstrated during the recruitment process (job interview, specialized tests, logical exercises), but also during the professional activity. The average grade attributed to young engineers’ theoretical knowledge is 7.23. Practical skills of young specialists meet 82% of employers' expectations. The average grade attributed to practical skills is 6.55, in such a way reflecting predominantly the theoretical character of university and professional studies.

There was a fair degree of consensus amongst employers about the kind of skills that they sought from new graduates. In general, these included leadership, team working, communication and interpersonal skills, analysis/problem-solving, creativity/innovation, planning and organizing, business understanding/commercial awareness and performance. Whilst most employers were satisfied with the quantity of applicants, they would have preferred better quality from which to select. Vacancies often remained unfilled owing to a lack of suitable candidates. This was particularly the case with electronic and electrical engineering graduates, although some employers had identified other shortfalls and many referred to the perennial problem of recruiting women engineers. Many employers also felt that good graduates were attracted to better-paid jobs elsewhere, for example in the financial services sector. Many employers stated that graduates often lack the ability to apply their technical skills and knowledge in a business or workplace context, describing this as not just the ability to recall engineering principles and techniques (important though this is), but also an almost innate feel for how these could be applied to a particular problem.

Young specialists’ key skills, considered by employers' representatives as being very important, on a scale of 1 to 5 (where 1 is not important and 5 - very important) are as follows: education level (average grade: 4.43) ; attitude towards improvement (average score: 4.32); qualification (average score: 4.30); teamwork skills (average grade: 4.30); computer skills (average grade: 4.25); attitude towards work (average grade: 4.07); foreign languages (average grade: 4.07); flexibility (average
score: 4.02), table 1. More than half of the study participants considered these knowledge, skills and abilities to be very important.

**Table 1. Importance of young specialists’ knowledge and skills in the employers' vision.**

| Importance level | Skills and abilities               | Average grade (1-5) |
|------------------|-----------------------------------|---------------------|
| 1                | Education level                   | 4.43                |
| 2                | Attitude towards improvement      | 4.32                |
| 3                | Qualification                      | 4.30                |
|                  | Teamwork skills                    | 4.30                |
| 4                | Computer skills                    | 4.25                |
| 5                | Attitude towards work             | 4.07                |
|                  | Foreign languages                  | 4.07                |
| 6                | Flexibility                        | 4.02                |
| 7                | Seniority in work                 | 2.73                |
| 8                | Age                                | 2.45                |
| 9                | Gender                             | 2.16                |
| 10               | Appearance                         | 2.07                |

We believe that having of skills above written would help to increase to increase the young professionals’ employability and strengthen trust and collaboration relations between the education and the labour markets.

### 4.3. Questionnaire „young specialists and labour market”

Analysis of the search job presents different situations depending on young specialists’ personal factors (desire to seek or not a job, motivation to work, expectations towards the work and the employer, correlation between time work / personal time, etc.) and contextual factors (economic, political, social, labor market trends, etc.).

After analysing the research results, in the period immediately following the university graduation, from the total number of respondents:
- 52% attended master's courses in the country and abroad;
- 84% are employed according to their specialty;
- 17% are employed in a field other than the graduated one for various reasons ("for a higher salary", "because I have more free time", "combine master studies with the job", "I'm on vacation for child care and have part-time work");
- 34% continued their job where they were already working during their studies;

Entrepreneurial spirit is proper for a small percentage of young engineering specialists, so, only 4.33% of respondents said they launched a business after graduation.

The employment immediately after graduation is important to strengthen knowledge gained during the university years, but also to strengthen the positive self-image. Searching and finding a job for engineering professions as usual does not take much time, about 2-3 weeks.

Regardless the time a young specialist becomes employed, the job searching process consists of several complex stages, including contacting employers, drafting and sending Curriculum Vitae and cover letter, interviewing (directly, by phone or Skype). Respondents have mentioned that about 6% did not contact any employer, but the company contacted them about the job offer. This fact is due to the existing collaboration between high education institutions and institutions, enterprises and
organizations; deans, heads of department and teachers are often asked to recommend good graduates. Most of the young specialists (27.71%) contact a single employer and then engage themselves.

Graduates of the Engineering specialty (from “Alecu Russo” State University Balti) have, from the very beginning, assured work places at ICS DRA "Draexlmaier Automotive" SRL, Inspectorate for Technical Testing of Cars, "Moldagrotehnica" S.A., road transport companies, etc.

We have to specify that involved in the research young specialists’ first job corresponded 88% with the graduated specialty.

Many respondents are satisfied with their current professional position, assigning grades of seven (6.4%), eight (38.31%), nine (29.10%) and ten (11.64%) on the scale of 1 to 10. The average score held on position conformity is 8.2.

Another topic analysed in the present study is related to analysing and comparing the expected and de facto salary (figure 3):

![Figure 3. Compared analysis between the expected salary and de facto salary.](image)

It is noted that the majority of employed respondents have an average monthly earnings of about EUR 250 (35.4%), while the desired earnings are EUR 450 (37.9%).

The size of the desired salary stems from all the needs of a young person to set up a family and to ensure a decent living. As a result, we were confronted with the exodus of young engineers towards countries with a more developed industry with higher living standards.

5. Engineers’ education and flexible training

It is necessary to elaborate a systemic approach to young engineer specialists’ socio-professional integration, taking into account all the problems listed above as well as perturbations may occur on the educational and labor market (figure 4):

![Figure 4. Systemic approach of the formative process.](image)
This flexible modular system will consist of several consecutive steps:

1) pre-university: recruiting and selecting young people with skills/aptitudes for Science-Technology-Engineering-Mathematics (STEM); applying special selection and training programs in high school (the last two years of high school).

2) academic education: a) basic training (mathematics, physics, biology, chemistry, computer science) and b) technical training on engineering fields.

3) Starting with the third study year, to select young people with a high conceptual potential, creativity and orientation towards design engineers, and young people with practical and technological skills for exploitation engineers.

4) The cycle II Master for engineer training will include Science Master and Technology Master programs. Master's thesis or technology project must be applicable within an enterprise. Therefore, its idea must be technically and technologically reliable, but it must also be economically efficient.

5) The whole training process of future engineers requires that during the six study years, they will have at least six months of practical training with validation of knowledge through a final evaluation at the company where the practice would be.

The graphic illustration of the modularized training system is given in figure 5:

![Modular training system](image_url)

**Figure 5.** Modular training system, [11].

Thus, the specialist will be able to work in industry, research, development or education at the end of the formative-educational process.

At the same time, the engineer will be able to select the branch the most appropriate for him: researcher, system designer, device / process designer or developer, product / process support or operations engineer, entrepreneurial engineer or manager by combining the multifactorial knowledge, skills and competences formed during the educational route (figure 6).
Figure 6. Professional engineering career tracks.

With this model, each engineer will be able to develop and be able to excel in a particular field with help of this model.

6. NAE grand challenges for engineering
The NAE grand challenges for engineering, created in 2008 in USA, presented an aspirational vision of what engineering needs to deliver to all people on the planet in the 21st century, [12]. In just 15 words, the vision it calls for is: “Continuation of life on the planet, making our world more sustainable, secure, healthy, and joyful”. The vision is about serving people and society, including everyone on the planet, and it is a century-long initiative.

Currently, engineering education programs in every country prepare students for careers in the culture of the home country, and the US is no exception. At the same time virtually all engineers agree that engineering in the 21st century is global. All engineering students graduating today will work globally, even if they do not believe so at the moment, and hence that it is important to prepare students graduating today for global engagement and the mind-set to work anywhere in the world in the 21st Century.

Engineering schools around the nation and the world, and even K-12 programs have adopted the NAE Grand Challenges to inspire practical projects for their students. The GCSP was proposed at the inaugural Summit on the NAE Grand Challenges for Engineering at Duke University, by the deans of the three founding GCSP schools Duke, Olin and USC. In 2009, the NAE moved to endorse this definition of a new engineering education supplement to any engineering program that adds global awareness and social skills with a focus on the Grand Challenges to broaden the reach of undergraduate study in engineering to the global community.

NAE does not dictate an engineering curriculum to any university. The GCSP simply identifies five competencies that a student must achieve to prepare them to address the Grand Challenges for Engineering found globally. Each adopting university defines its supplemental approach to educating its students about each of the five competencies during its undergraduate engineering degree program framework. In brief, the five student competencies in the GCSP are:
1. Talent Competency: mentored research/creative experience on a Grand Challenge-like topic.
2. Multidisciplinary Competency: understanding multidisciplinary of engineering systems solutions developed through personal engagement.
3. Viable Business/ Entrepreneurship Competency: understanding, preferably developed through experience, of the necessity of a viable business model for solution implementation.
4. Multicultural Competency: understanding different cultures, preferably through multicultural experiences, to ensure cultural acceptance of proposed engineering solutions.
5. **Social Consciousness Competency**: understanding that the engineering solutions should primarily serve people and society reflecting social consciousness. Addressing any of the Grand Challenges naturally spans multiple disciplines, and because Grand Challenge problem solutions are implemented in different parts of the world, students are prepared to think in international terms, and to develop globally relevant perspectives and skills. Anecdotally, the GCSP attracts students because it prepares them for real and urgent problems that need solutions; it is a basis for realistic experiments, homework and problem challenges in the field during their undergraduate years; and it offers a clear view to future jobs that matter and the opportunities in engineering that await them.

For the GCSP to be implemented at a university, the program must serve two masters: the student and the local university. It must be clear and focused on the value for the student. For the university, it must not impose added administrative requirements affecting its engineering program. Each university must have the autonomy to create its supplemental GCSP using its strengths and resources to instil the five competencies.

7. **Engineers' skills in the industry 4.0 framework**

   Industry 4.0 depends on small revolutions in different fields:
   - Applying information and communication technology to digitize information and integrate systems into the design, development, manufacturing and use of products.
   - New software technologies for modelling, simulation, virtualization and digital manufacturing.
   - Developing of cyber-physical systems to monitor and control physical processes.
   - Evolution of 3D printers and additive manufacturing to simplify production.
   - Decision support for human operators, appearance of smart tools and assistance using augmented reality. Many of these technologies are available for several years, but others are not yet ready to be used widely.

   The new industrial revolution comes with a lot of challenges. Industry 4.0, a collaborative and non-competitive industry like this one, will bring a higher level of automation and interconnectivity to the manufacturing process. Tools, technologies and machines that are going to be used are expected to be different from those currently available. Smart machines will co-ordinate manufacturing processes by themselves, and intelligent robots will work with assembly line workers both within an enterprise and globally with other partners from other national and international companies. Smart devices, such as tablets, information carriers, etc., will be used to collect and analyse information in real time. Therefore, the high education diploma will not be a sufficiently consistent argument for applying new technologies and recording technological progress.

   According to R. Berger, with the Industry 4.0 appearance, companies will not only face challenges in finding qualified employees, but also with several other challenges existing workforce and skills development programs, as it is mentioned below [13-15]:
   - Improving skills: Companies will have to improve their workforce through internal and external training centres, through programs of lifelong learning. For example, an assembly line worker involved in manual fitting of a part will be required to operate a robot or other tools to do so. He or she should develop skills to be able efficiently to operate new manufacturing technologies.
   - Re-empowerment: 4.0 industry is expected to cause a job displacement in some degree. Some jobs will cease to exist and others are completely new and different will be created. Companies will have to invest in retraining their workforces for this major change.
   - Lifelong learning: Technologies will be improved in a very fast pace. In this context, both natural and human thinking with artificial intelligence will work both in parallel and in tandem. Strategies of continuing professional development will be needed easily to adapt to changes brought by technological advancement.
   - Changing of attitudes: as the workforce should to be adapted to several changes, some resistance will appear. It will require companies to change its employees’ mentality to facilitate the transition to advanced manufacturing processes.
8. Conclusions

Engineering education is indeed one of the strongest pillars of economic growth and national development of any nation. The current trend in engineering education in the world and in Republic of Moldova has created a disparity between the quality of training received by the graduates vis-à-vis the employer’s expectations in the businesses and industries. It is obvious to note that the curriculum of engineering education needs to be reviewed in order to have a well-trained graduate that can compete with their counterparts globally, this could be done through university-industrial linkage that will give exposure to the students, reforming the teaching and learning methods through different methods that will make the students creative, focused and exposing them to different problems and challenges.

However, adequate provision of funds, creation of national skills centres, up-to-date equipment and facilities as well as the welfare of teachers is also a bridge towards achieving quality engineering education.

Other ideas to improve engineers’ training refer to the following:
- continuing education of engineers, as well as teachers, to increase the adaptability of the education system, implementation of economy principles based on knowledge, creativity and innovation;
- implementing innovative educational programs that meet requirements of the societal challenges;
- creating strategic partnerships between universities and companies to ensure the technological transfer;
- re-launching research programs in universities and predictive maintenance of funding viable research programs together with the economic environment.

9. References

[1] McCarthy N 2015 The Countries With The Most Engineering Graduates available online at: https://www.forbes.com/sites/niallmccarthy/2015/06/09/the-countries-with-the-most-

[2] World Economic Forum. Employment, Skills and Human Capital Global Challenge Insight Report. The Human Capital Report 2015 available online at: http://www3.weforum.org/docs/WEF_Human_Capital_Report_2015.pdf, accessed at: 20.02.2019

[3] Beanland D 2012 Engineering Education: The Need for Transformation A Monograph commissioned by UNESCO (Melbourne Australia)

[4] ANET. Scoping our Future. 2010 available online at: http://www.anet.org.au/wp-content/uploads/2010/12/Scoping-our-futureWEB.pdf, accessed at: 20.02.2019

[5] Investing in a localized world AT Kearney Global Business Council 2018 available online at: https://www.atkearney.com/documents/20152/1083013/2018+FDIC+Investing+in+a+Localized+World.pdf/ff9590ce-2328-39a8-6609-16643f5ea30d?_=1540309700333, accessed at: 10.02.2019

[6] Ciobanu R M and Nedelcu D 2007) Organizational reengineering--an approach of change for the Romanian companies Annals of DAAAM & Proceedings pp 147-149

[7] Ciobanu R M, Nedelcu D and Condurache G 2008 Continuing education in project management—a requirement from Romanian higher education Proceedings of the 5th International Seminar on the Quality Management in Higher Education pp 167-172

[8] National Bureau of Statistics of Republic of Moldova available online at: http://www.statistica.md/pageview.php?id=407, accessed at: 10.02.2019

[9] Garbuz V 2018 Perfectionarea procesului de integrare a tinerilor specialiști cu studii superioare pe piata muncii din Republica Moldova PhD. thesis available online at: http://www.cnaa.md/files/theses/2019/54272/veronica_garbuz_abstract.pdf

[10] Garbuz V and Topala P 2017 Economic Mechanisms of Influence on the Development of Human Capital Trained in Research International Journal of Modern Manufacturing Technologies IX(1) 25-34

[11] Lorentz M, Rusmann M, Strack R, Lueth K L and Bolle M 2015 Man and Machine in Industry 4.0: How Will Technology Transform the industrial Workforce Through 2025? The Boston
Consulting Group available online at: https://www.bcgperspectives.com/content/articles/technology-business-transformation-engineered-products-infrastructure-man-machine-industry-4.0

[12] NAE Grand Challenges for Engineering. available online at: http://www.engineeringchallenges.org, accessed at: 17.02.2019

[13] Berger R 2016 Skill Development for Industry 4.0 2016 available online at: http://www.globalskillsummit.com/whitepaper-summary.pdf, accessed at: 20.02.2019

[14] Hozdic E 2015 Smart factory for industry 4.0: A Review International Journal of Modern Manufacturing Technologies VII(1) 28-35

[15] Richert M, Shehadeh L and Plumanns K 2016 Educating engineers for industry 4.0: Virtual worlds and human-robot-teams. Empirical studies towards a new educational age Global Engineering Education Conference (EDUCON) 2016 IEEE pp 142-149 doi: 10.1109/EDUCON.2016.7474545