Analysis of ICT Application in Technology Transfer Management within Industry 4.0 Conditions (Education Based Approach)

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Abstract. The article deals with the analysis of information and communications technologies (ICT) role in the interaction of Higher Education Institutions (HEIs) and industry in the context of Industry 4.0 industrial system formation, as well as the implementation of the world experience in ICT-innovations applications in technology transfer and production processes. The study is based on the idea, that within Industry 4.0 HEIs are becoming the centers of technological clusters and networks and therefore education in such zones should be focused on achieving of real project results, conducting practical research in conditions of access to huge volumes of information, especially experiment data and tacit knowledge exchange. So it is proposed to consider ICT role within the HEIs place in Industry 4.0 innovation system, which requires new skills. Authors have considered the main Industry 4.0 trends within the education foresight methodology. Based on research results the main directions of ICT-innovations application in technology transfer system were formulated. The main issues and cases of ICT application in HEIs for technology transfer management thought the information-technology support of client-oriented approach to educational programs formation and the creation of smart environment of HEIs were considered. ICT role in educational engineering within the framework of HEIs strategy development at different levels as a mechanism for overcoming the contradictions between the prospective professional competences and the requirements from industry was considered. The given recommendations can be used by policy makers, managers of education and/or R&D organizations within the technology transfer and innovation education technologies implementation projects to improve the interaction between HEIs and business.

Keywords: Digitalization, Technology Transfer, Cooperation, Education, Industry 4.0, ICT, Innovations.

1 Introduction

The global economy is at the stage of transition to 4th technological revolution, which is based on the different solutions of network and adaptive production with intelligent systems. However, in order to take all advantages of Industry 4.0, the radical changes in the labor market are needed according to the changing requirements and, as a result, in education concepts, since human capital is the Industry 4.0 key success factor.

Therefore, now the nations need to start radically rebuilding the higher education system as a source of intellectual resources, modernizing the information and innovation communications of Higher Education Institutions (HEIs) infrastructure in order to create qualitatively new jobs and improve the technology transfer within the framework of business to education (B2E) & education to business (E2B) linkages.

Today the problem when the traditional education system prepares specialists for professions, which by 2020 can be partially or fully automated, is already clearly visible. All these professions require the routine work for execution, while the professions of the future are oriented to diverse social and creative skills, the ability to make decisions in uncertainty conditions and the ability to implement of complex projects. Thus, it is quite obvious, that the classical education system is obsolete and on the eve of the 4th industrial revolution calls for radical changes of R&D models.

At the same time the world leading manufacturers are already obtaining the benefits from advanced solutions (primarily from new generation of ICT solutions, especially intelligent systems). The survey, conducted by the American Society of Quality in 2014 among the manufacturing sector representatives, has revealed, that 82% of organizations, switching to «smart» production, have reported about an efficiency increasing, and 49% have noted the product defects number decreasing and another 45% have reported about the customer satisfaction increasing (Griffith).

Nevertheless, any manufacturer to obtain benefit from the transition to the future factory technologies, need to attract the qualified technical specialists, who are able to work with new virtual models of technology transfer as production base paradigm in the physical space and understand, what is required from them in new conditions of Industry 4.0. This is becoming a new kind of challenges for HEIs and education technologies (EdTech), so some leading world educational organizations with technical priorities already are actively developing of new approaches to training staff with the appropriate skills required in the future Industry 4.0 factories.

In these conditions the developing countries, those are not easily transitioning to the digital platform economy because of absence of global oriented national digital platforms and successful companies operating in new high-tech markets. In general, the digitalization of production and technological processes goes in information and communication technologies (ICT), finance, trade and some other service sectors. But these achievements could not provide stable competitive base of nation.

Experience of USA, EU, Japan and China, which hold the first positions in the production of applied full-fledged digital platforms in science, telemedicine and industry and other sectors, which are based on active cooperation in the framework of business to education (B2E) & education to business (E2B), clearly demonstrates the necessity of system policy of ICT development, which includes strong education component and important role of HEIs in technology transfer. This component is based on new education models within Industry 4.0 development patterns and includes science and technology transfer as an education technology. So in order to catch up with the competitors and to develop of applied digital technologies to solve different social and economic development problems, it is necessary to move the whole higher education system linked with economy quickly and systematically into the digitalization zone.

2 Study of Modern Trends and Important Implications

In our study we will use the McKinsey & Co definition of term «Industry 4.0» as «digitization of the manufacturing sector, with embedded sensors in virtually all product components and manufacturing equipment, ubiquitous cyber-physical systems, and analysis of all relevant data» (McKinsey & Co., 2015) [17]. From given definition we can underline the critical role of ICT in manufacturing systems, which forms specific task for education.

Within the EdTech and HEIs development priorities study we note the ideas of Shelzer R. (2017), the expert of Global Electronic Services, underlines, that in social environment terms Industry 5.0 will return focus to human dimension of manufacturing whereas Industry 4.0 is primarily focused on the technological development issues. E.g. with this focus returning to human, the fifth industrial revolution may require a new manufacturing role – Chief Robotics Officer (CRO) [28]. This position will require the experts, who specialize in human-machine connectivity and will be responsible for all things from making decisions on which machines or devices to add to the plant to improving of strategies for the production line optimizing [16].

In this example we can observe the necessity to create the new framework of strategical cooperation, especially between the ICT sector and humanitarian sciences through the digitization [4; 18; 25]. The main dimensions of innovation communications according to (Pfeffermann, 2011) are derived from the conceptual definition of innovation communication and understood as the constitutive elements of the dynamic innovation communication capability [21].

This idea can be explained by Kelli [10], which underlies, that each person in the future will face with the «newbie fate», when we will just struggle to keep up with the progress, because of such main reasons:

- majority of the most important technologies, that will determine the life and competitiveness in the next 15-20 years, have not yet been invented, so they will be new to the business and society;
- new technologies require endless updates and users will constantly be in the status of newcomers;
- today the technologies obsolescence cycle has significantly accelerated (for example, applications for phones remain relevant for an average of only a month), users simply do not have enough time to master everything in a perfect way, until something else will replace it.

From the point of view of the business strategy, these reasons lead to a constant search for ideas and a rapid innovation process, which forms new tasks for HEIs, especially future engineering education.

According to studies [6; 7; 8; 26] there are such implications for the future engineering education in Industry 4.0 conditions:

1. Excellence through the interdisciplinarity, which is based on the ideas, that without interdisciplinary cooperation there are no innovations; highly complex socio-technical systems development requires the various academic experts collaboration; future engineers need the skills to «look beyond their own nose»;
2. Adaptability to the rapid innovation cycles («half-life» of knowledge sector is shortening rapidly; students need less detailed specialized content than the lifelong learning ability; future engineers need the skills to adapt to rapid changes);
3. Survival in Industry 4.0 conditions requires good IT skills (IT is the main driver of innovations in future industrial context; independent in specialization engineers should have the basic knowledge for understanding of others; future engineers need to be able to «speak code» as a new competence);
4. New business thinking (above the basic classical skills to manage projects, future technological entrepreneurs need of additional skills, particularly leadership, decision making etc.; they need to know how to communicate in business ideas with different stakeholders; future engineers need to know how to collaborate);
5. Taking risks and dealing with uncertainty (uncertainty cannot be managed and even the best prediction will end up as «only partially correct» and that's why good predictions need some time, which is lost for other things; future engineers need to be unterrified and capable to adapt to the changes quickly and through the broad competencies);
6. Bursting with creativity (when the speed of innovation cycles increases, creativity becomes the "new gold" in business; students need the ability to critically assess different issues and to develop responsible and creative ideas and solutions).

In all of above mentioned points ICT play a significant role, because they allow to create appropriate education framework and environment for (1) interdisciplinary cooperation through the simulation and models (e.g. these are already used within the new nanomaterials development [30]); (2) lifelong learning as an education tool; (3) coding base which is an element of digital competence; according to forecasts, in the next 10 years the number of jobs requiring programming skills, will grow faster than other labor market positions; (4) business already requires a culture of interaction, when managers and professionals can exchange information that is important for improving processes and efficiency increasing, as well as for eliminating problems and adapting to changes; (5) ICT can be considered as a tools for uncertainty reduction i.e. it can automate the process of situation assessing and decision making under uncertainty conditions; (6) creativity can be developed by providing training in modern and promising IT by including the student in the process of knowledge obtaining, new IT solutions and new technologies development within the Smart Education framework.

Analytical materials [2; 11] show, that the forthcoming technological revolution must turn the educational system towards the training of predominantly new-quality technical personnel, the deficit of which will create problems in technology transfer for science based business and state as well.

In view of the foregoing issues, the problem of choosing a strategy and directions for technological development for different entities is somewhat simplified and can be conditionally reduced to the task of current demand analytics in the labor division global system. Meanwhile, despite the presence of significant number of economic and technological forecasts, as well as foresight researches, the task of selection of technological development promising areas for regions, companies, HEIs and other entities is not a trivial [12; 24], because of such points:

- these documents are largely generalized and do not fully take into account the specific features of particular region or company. In addition, as a rule, technological areas are also considered in aggregate form. In this case, technologies in the age of 2-3 years can be identified within the technological field actively developing on a global scale, which has been developing for several decades;
- in order to find own place in the technological trend, it is necessary to examine and objectively evaluate own competencies, as well as the market needs;
- taking into account that many technologies have global distribution, applications and markets, it is important to take into account the possibilities of collaboration with domestic and foreign partners in R&D, as well as possible limitations determined by state regulations, and in some cases, sanctions or restrictions (e.g. intellectual property or export).

Thus, when choosing the strategy and directions of technological development, the subjects acquire special importance the tools and methodology of detailed research of technological and competitive aspects of perspective directions of development.

Realizing this, the world's largest IT companies are already laying out in their strategies the popularization of programming and engineering through the cooperation with the educational sector, treating it as a source of staff and ideas.

Apple launches Swift playgrounds to teach children programming, and the creators of the largest organizations sponsor the online platform code.org. Different components are developed at a tremendous speed, which leads to the fact that now the child can assemble the desired construction from LEGO Robotics or take the Arduino controller and create something completely unique.

In 2014, developers from Osmo have created the game Osmo Pizza, which taught children the basics of programming. It was included in the list of 25 best inventions of the year according to Time Magazine. Tynker plans the introduction in more than 60,000 US schools to teach children the basics of coding through the programming of Parrot drones. It is possible, that soon we will see kindergartens, where educators with tablets will teach children in foreign languages, mathematics and programming. All this is the first stage of training future specialists for the industry 4.0. If children do not begin to teach technical principles from an early age, then in the future it will be increasingly difficult for them to adapt to the professional environment.

Modern technologies accelerate the learning process and also help the trained professionals in the work. And this concerns not only artificial intelligence application. In the near future, virtual reality technologies will help medical students to perform practical operations without harm to patient.

Another example of new technological level is Next Galaxy Company, which creates a single social VR platform CeeK. The plans of developers include making a whole virtual world with shops, meeting places and classes for training.

These examples illustrate the moving towards new development approaches, but within the framework of national development programs and implementation of national priorities as well as priorities of education system as a base of national innovation system, HEIs also have an important role to play.

In United States, that is an example of nation, where the system of forecasts is directly implemented into the state policy in order to achieve the national competitiveness, since 2012 there is a non-profit Coalition of Smart Production Leaders, which, in addition to business entities, includes state agencies, HEIs and labs. Also in USA, the US Production program is being implemented, within the framework of which it is planned to create up to 15 applied research institutes for innovations development in the manufacturing industry (IMI) in such areas as sensors, optics and photonics, materials, artificial intelligence, robotics, modeling, additive production, 3D-printing etc.

In Germany the platform «Industry 4.0», which was created in 2013, is one of the key development mechanisms. It works in 10 strategic development directions: creating conditions for Industry 4.0 technologies transfer to SMEs, cyber security, regulatory, best practices demonstration, Industry 4.0 technologies standardization etc.

Analysis of all these examples demonstrates the key role of ICT, which act as an instrument for creative skills developing, as well as a promising direction for the development of E2B & B2E as well as S2B & B2S cooperation. So in the world practice, the most successful HEIs combine scientific, engineering, humanitarian, medical, business schools and faculties in their campus. As a result, a competences complex arises, that can be used to implement projects of any complexity. This is appreciated by global companies and creates an effective entrepreneurship environment.

According Marvin Liao, partner of 500 Startups Foundation, [29], there are many factors, that confirm the promise of work in the field of EdTech. On the one hand, this is a reduction in the cost of consumer goods, on the other it's still high prices for education, for example, in North America. Despite the fact that in many countries the sphere of education is subject of very serious regulation, in the next 10 years exerts expect the development in this area as well.

The development of proactive strategies is prompted by forecasts according to which the repeated change of professions will be a characteristic feature of the Industry 4.0 economy (according to estimates of City&Guilds, Great Britain, by 2025 people will change their profession up to 19 times), and the fact that professional knowledge quickly become obsolete (annually in the world economy more than 500 professions dies, more than 600 appear). In a number of industries, innovation cycles are shorter, than the time required for appropriate specialists training.

In Ukraine, the strong engineering competencies are not backed up by business skills, scientific schools lack engineering, there are practically no incorporated medical schools anywhere.

In current conditions in the Ukrainian ICT industry there are practically no well-established connections between HEIs and business, scientists and infrastructure, the state and start-ups, which leads to the loss of development resources. There are no efficient companies (networks) for technology transfer, venture funds and full-fledged intellectual property protection. It is difficult to interact with industry in the absence of special services in many HEIs, which monitor personnel requirements, evaluate potential cooperation opportunities (E2B & B2E, S2B & B2S), plan research and implement their results. As a result, potential customers have fragmentary information about the scientific and production capabilities of HEIs and are practically unaware of the competitive developments. Let's note, the same situation is observed in other high-technological sectors, which creates threats to national security through the possibility of reaching to the global innovation development periphery.

The special importance of technology transfer in the HEIs development is caused by the fact, that education quality implies two components: getting new knowledge and it integrating into the real life (production). Only the fulfillment of both points makes it possible to obtain practical skills, which will help in development purposes.

So the **purpose of this study** is to analyze the role of ICT in the interaction of HEIs and business in the context of Industry 4.0 industrial system formation, as well as the introduction of world experience in using ICT-innovations in the technology transfer and production processes. Based on the results of the research, the main directions of the work on the introduction of ICT-innovations in HEIs technology transfer system will be formulated; obtained results can be used to develop projects to improve the interaction between HEIs and business.

3 Methodology

In UNESCO documents, education technology is considered as a systematic method of creating, applying and defining the entire learning process of teaching and learning, taking into account technical, human resources and their interaction.

In this case the efficiency of ICT application and technology transfer is determined, first of all, by an adequate organizational system, oriented to ensuring the process of R&D results transfer into production and their subsequent distribution in the economy.

For the development of educational system adequate to Industry 4.0 we propose to use such methodological points and suggestions.

First of all we propose to conduct the technological trajectory analysis in the context of innovation management framework (high-tech case) [14], which gives possibility to form the vectors of education system development according to future technologies, e.g. considering the role of ICT as connecting link.

We also propose to consider ICT role within the HEIs place in international innovation networks, which are the new stage of innovation development [3; 13] and requires new skills.

In our previous studies we have considered strategycal aspects of technology transfer in metallurgy [19] and technological package concept for space metallurgy development strategy [20]. These ideas were based on different ICT tools applications, which help to unite various technologies within the complicated technological systems (firstly within some theoretical models and simulations) and manage them.

Another aspect of Industry 4.0 implies the rational use of natural and technical resources, the most effective energy saving, recycling of all waste and the receipt of new products, raw materials or energy from them [15]. This aspect also deals with the education and transfer of energy efficient technologies.

We propose to consider all these aspects within the education foresight methodology. Generally foresight is a system of methods for expert evaluation of strategic directions of socio-economic and innovation development, identifying technological breakthroughs, that can have an impact on the economy and society in the medium and long term. Expert assessments are the basis for the future options evaluating. Foresight methodology has absorbed dozens of traditional and fairly new expert methods. At the same time, their continuous improvement and development of methods and procedures are taking place, which provides an increase of the prospects for scientific, technical and socio-economic development foresight validity.

The information base of the educational foresight includes analytical reports of international organizations, materials of foreign foresight centers, forecasts of large corporations and private companies, data of consulting agencies, national forecasts of scientific and technological development of various industries, databases of scientific publications, patents and dissertations and other sources.

The main vector of foresight methodology development is directed to a more active and focused use of the knowledge of experts participating in various projects. Usually, each of the foresight projects uses a combination of different methods, including expert panels, Delphi, SWOT-analysis, brainstorming, scenario building, technological roadmaps, relevance trees, mutual influence analysis, etc.

Within the purpose of this study we underline, that foresight proceeds from the idea, that the onset of future desirable version largely depends on the actions taken today, so the choice of options is accompanied by the development of measures that ensure the optimal trajectory of innovation development.

Most foresight projects as a central component include prospects of science and technology development. Usually these issues become a subject of discussion not only for scientists, but also for politicians, businessmen, practitioners from different sectors of the economy. The result of such discussions is the emergence of new ideas related to improving the mechanisms for managing science, integrating science, education and industry and, ultimately, increasing the competitiveness of the country, industry or region.

Having an idea of the potential of digital transformations and the principles of integrating a physical plant with a real-time digital model that bidirectionalizes what is happening in the virtual and real worlds, HEIs will be ready to occupy a niche of future experts and active participants in the industry economy.

In Fig. 1 we have shown the basics of foresight application for higher education digitization according to technology transfer development.

We believe that analysis and forecasting within the education and technology transfer objectives should include:

– formation of data on the state and prospects of the industry development in the

country and abroad;
- monitoring and analysis of production and sales volumes at home and abroad;
- expert-analytical studies in the development of strategic industry documents;
- monitoring of measures of state regulation and analysis of their impact on the development of the industry;
- analysis of key technological development trends: global prerequisites, key challenges and risks, international experience, current status, etc.;
- examination of investment and innovation projects of the industry development.

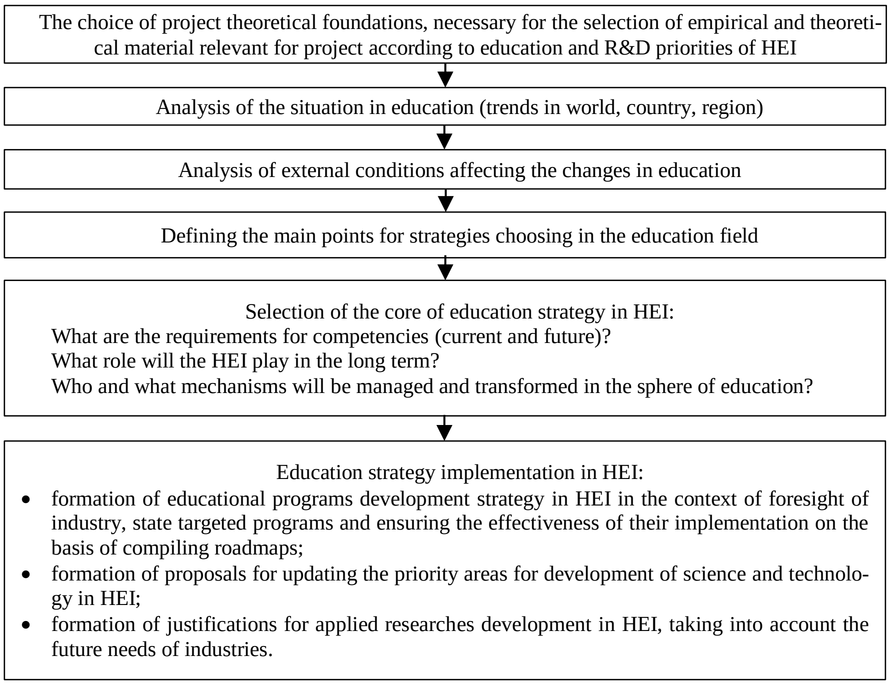

Fig. 1. Education foresight framework in HEI.

According to Fig. 1 we see, that in conditions of HEIs autonomy the new strategy should be developed by each HEI according to its specific, so the role of innovations (organizational and technological), particularly ICT, is growing.

4 HEIs Technology Transfer Models Evolution

From the previous points we can conclude that in education an era of radical change is coming. For a very long time this sphere could afford to be immune to all possible to changes in society so that behind it the reputation of one of the most conservative areas of human activity was fixed, but in Industry 4.0 times the situation is changing. The next 20 years will be the period of the most radical changes in education, perhaps from the moment, when national educational systems was created. And the main source of these changes will not be the education system itself, but linked industries and technologies, which will come along with a change in the technological era.

Based on analytics of foresight studies and world ranking methodology the evolution of HEIs models according to ratio of three criteria (integration of R&D activities in education process, cooperation with business and society, digitization), was developed (see Fig. 2). According to Fig. 2 innovation production become the main functions of University 4.0, as well as the formation of communities of a new level – «thinking environment».

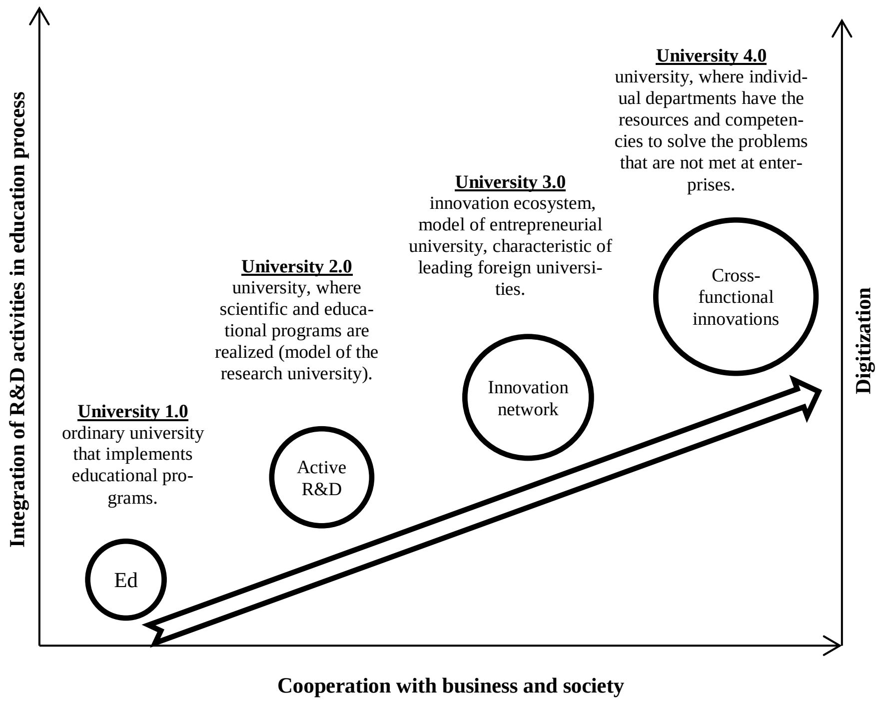

Fig. 2. University models evolution.

As part of digital economy within Industry 4.0 development, HEIs are becoming centers of technological clusters and networks (innovation zones), such as it is in the Silicon Valley and Stanford University. Education in such zones is focused on achieving real project results, conducting practical research in conditions of access to huge volumes of information, especially experience data and tacit knowledge exchange within the cooperation technology transfer models. A new environment around HEIs (so called "innovation ecosystem") helps to form consumers (particularly through the spin-offs) with a new way of life that will stimulate a cyclical demand for innovation.

According to these trends up to 2030 a «flipped university» can become a typical educational model, in which training is conducted through mass open online education platforms such as edX, Coursera, etc., and only the laboratory works, training projects and lively discussions will be realized in HEIs. Education 4.0 allows the use of different educational practices: mixed instruction, individualization, project work and adaptive learning.

It should be noted, that an important condition for domestic R&D sector effectiveness increasing is the implementation of measures to deepen the integration of science and education, including, in particular, the creation and development of integrated structures: departments and laboratories of HEIs in academic institutions, university and interuniversity complexes, educational & industrial centers, specialized (sectoral) research HEIs and departments.

In new conditions it is no longer the main question of how to develop a product and promptly transfer its technology to production. To create a finished product we require a holistic approach to its development and production. Therefore, there was a need for a global change in the education principles with the transition to holistic learning in order to catch up with the emerging in industry trends.

The use of digital and virtual engineering makes it possible to carry out research and development in computer-aided design systems, which affects the quality of the product and the timing of product withdrawal to the market. Industrial Internet, which involves connection to data networks of various production systems, allows to receive the necessary data in a timely manner and to act remotely on equipment, which ultimately affects the increase in production efficiency.

So the new EdTech should include collaborative activities, digital support systems (augmented reality), automated vehicles, predictive maintenance, cloud technologies, sensor materials and stand-alone components, advanced analytics (analysis of big data), intelligent planning and production control are part of technologies list that gradually are transferred to industry and allow enterprises to reduce production costs and energy consumption, increase labor productivity etc.

5 ICT-Based HEIs Strategy

In the context of education strategy in the new information and communication environment discussion, it is necessary to take into account that there are more complex tasks, that some HEI alone are not capable of, so HEIs need cooperation with foreign and most advanced HEIs, large world companies that have their own large departments of strategic planning of the educational market.

Digitization is connected with important task of HEIs open information exchange system with the external environment development. For these purposes, it is necessary to create communication platforms in HEIs for representatives of state authorities, business, scientific and educational and expert community, as well as civil society. It is also important to establish mechanisms for systematic interaction with graduates, to implement programs of sociological and monitoring research in the field of science and education, and to create open e-libraries of research papers of employees and materials of conferences, held at HEIs.

These all tasks are based on understanding, that within Industry 4.0 the employer can be considered as a source, which allows HEIs to create the necessary interdisciplinary educational programs and to adjust research strategies with strong evaluation and feedback component. As a result, emerging market the needs must find a rapid response in education. So we came to the individual education paths formation according to customer requests, which is caused by such reasons and education trends:

- new players (informal educational institutions, corporate programs, online platforms etc.) already offer individualized educational products, that meet the needs of students and, what is the most important, employers;
- the number of informed students (so called autodidacts), who are able to formulate their learning goals and necessary competencies set, is growing;
- demand from employers for specialists with a certain and confirmed set of topical competencies, that are able of bring innovation ideas to company without any time gap, is growing.

To meet all these challenges and to achieve all these goals, each HEI needs a strictly individual strategy of digitalization, and it is not tied to the learning process, but to practical scientific activity and to existing and future developments.

The main here is the fact, that within these trends, ICT allow to return the individual approach to the center of the educational process within the competence model.

When the HEIs will combine digitization and R&D strategy we can create «growth points», that will prove the effectiveness of ICT in practice, and at the same time the ICT modernization strategy will have a deterministic character and will be based on the real strategy of HEI development as a scientific & educational organization, and not from the some abstract representations.

At the same time despite the some sectoral differences, HEIs have common tasks and ICT tools, for example:

- creation of databases, systems for questionnaires and entrants tests processing, archives of specialized literature and scientific works, information visualization systems;
- creation of complexes for creating 3D-audiences, many screen projection systems, transmission and reproduction of visual information over a wireless network;
- digitization of auxiliary activities management. Most HEIs primarily automate financial and HR activities. But the systems of educational process management, electronic training, document circulation and automation of libraries are also claimed;
- equipment and other resources for data centers creation, network infrastructure systems and labs for experiments with hardware and software solutions.

Another part of digitization and R&D strategy deals directly with Industry 4.0, which is based on new skills.

As part of the HEIs education strategy for Industry 4.0, it should be noted that the students will have to master three non-traditional skills.

The first point for students will be understanding the principles of hybrid work system application in the combination with technical assistance and cyberphysical systems.

The second point deals with the digital design environment. In the past, students had to deal with one thing: only with CAD systems, process engineering or robot modeling, in Industry 4.0 they have to work with all three digital tools that are used in modern first-class production.

The third point deals with the ability to manage intellectual production, proceeding from the extremely diverse requirements of customers, taking into accounts both the autonomy of technological systems and their interconnection.

Such skills requires abandoning of traditional education methods, when subjects are broken down into disciplines, so that students can gain a comprehensive understanding of the interrelationships and interdependencies between mechanical, information and automated processes.

Thus, an important aspect of HEIs adaptation to Industry 4.0 realities is the search for technological and ICT solutions to implement the above-described trends in the formation of educational programs and the transition to a new model of the scientific and educational process and to support the full life cycle of scientific and educational products (real education projects), taking into account its ties with the real sector of the economy.

In the near future, those universities, that will be able to use the ideas laid down in Industry 4.0 concept, will be competitive in order to individualize the trajectories of preparing graduates in the format of Lifelong Learning.

Based on the analysis of research [27] and models of competences, developed by the Employment and Training Administration (ETA) and Automation Federation of Industry experts [1], and approaches, considered in study [22], information-technology support of client-oriented approach to educational programs formation and the creation of HEIs smart environment of technology transfer can be realized through the application of such ICT groups within the ICT package of HEI (see Fig. 3).

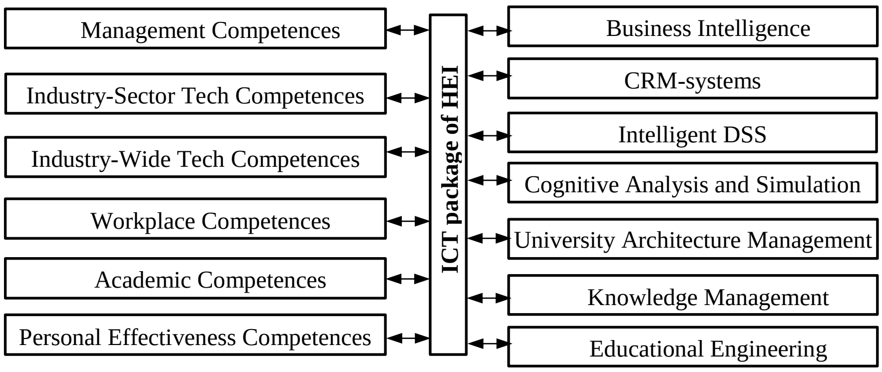

Fig. 3. ICT tools for technology transfer competences development in HEIs.

The simplest effect for the new EdTech deals with the animations based on Flash technology, mobile applications tools and media services application.

Educational engineering in the framework of HEIs strategy development at different levels can be considered as a mechanism for overcoming the contradictions between the wording of professional competences from educational standards and the requirements of labor functions from professional standards.

Among the engineering methods the information and educational space semantic modeling methods can be highlighted, which make it possible to systematize knowledge of professional field in the form of conceptual models of ontologies and repositories of educational objects [5], which will later be used in the design of curricula, course content and education strategy based on real projects.

Business Intelligence systems as set of technologies, software and practices aimed at achieving business goals by making the data best application available can help to solve different analytical tasks of HEIs R&D management (R&D priorities selection, cluster policy etc.).

Also within the smart environment of HEIs we propose to consider the management of HEI architecture based on University Architecture Management, which can help to adopt the university processes to new environment.

6 Conclusion

The fourth industrial revolution encourages everyone to adapt faster and, therefore, the situation, when success is achieved by those companies that work closely with universities and startup centers and introduce modern technologies in production, is clearly visible. Development of almost every of the basic industries of Industry 4.0 is impossible without solving the staff issue, as well as the creation and implementation of innovation technologies. So the range of the digitalization and technology transfer problems in the context of Industry 4.0 formation is aimed at the integrated development of HEIs` ICT based innovation ecosystem, synchronization of work with the innovation infrastructure objects, cooperation development with high-tech business in the frame of personnel training, applied research implementation and intellectual activity results commercialization.

In these conditions ICT application strategy should be aimed at supporting the creation of integrated education programs, which include the training of personnel, who have the necessary skills and knowledge to work in the new environment of Industry 4.0 through the new technology transfer models. Also, in the framework of development strategies we need to consider such main aspects of digitization:

- creation of digital competencies centers and stimulation of applied research and development within the education process;
- development of high-speed and reliable data transmission networks for educational and analytical purposes;
- creation of pilot digital factories to popularize the digitalization process across the entire spectrum of HEI specialties;
- raising awareness in the business environment of new opportunities and the need for cooperation with HEIs;
- creation of new type of network technology transfer tools based on the smart production with its combination with education (“R&D + EdTech” model);
- creation of specialized communication platforms with business in Industry 4.0 areas.

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