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INDUSTRY 4.0 REQUIREMENTS FOR QUALITY OF HUMAN CAPITAL AND COMPETENCES FORMED WITHIN EDUCATIONAL INSTITUTIONS

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Abstract

The connected factories and the internet of things raise new concerns in the field of the future competences that will be required by the labour market and that should be formed by academic institutions through educational programs. The new technologies and the digitalisation of everything will change the structure of the skills needed for enterprises; thus, the new human beings' role will arise. In this context, machines will replace people at the routine functions including the simplest decisions to be made, but the human beings should be able to check, to control and to correct the functioning and choices made by machines. The machine learning algorithms compete with the traditional system of humans training; the division of labour is to be extended to the division of education.

The academic institutions are looking for new functional roles in the societal and social-economic space. The future business will need the innovative reasoning and competences of making choice in complex changing environment with an infinite diversity and deep humanity as a determinant for profitability. Education as traditional transfer of knowledge looses its importance due to the overload of information in the Internet, but its role even increases for transmission of culture and of thinking.

This conceptual paper reveals essential features of the new functional and system roles played by the educational institutions within the industry 4.0 context, taking into account the combination of the total digitalization and the global knowledge society fostering.

Keywords: Knowledge transfer, education, human capital, competencies sharing, social networks, industry 4.0, connected factories.

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1. Introduction

Society' evolution represents the changes from the mass production, aimed to satisfy the basic human survival needs, towards the individualized products (with 3D printing) and services (the complex system "product-service") targeted to better meet the personal needs through more differentiated approaches. The developed countries have almost solved the task of surviving for their population; the globalization represents the tendency of deploying the satisfaction of the basic needs (by profit-driven corporations) to the global population.

With the evolution of the information society and digital economy, the ICT progress, the development of knowledge management and cognitive economics, the human and social regulatory mechanisms are to be changed (Pokrovskaia, 2014). The economic agents have to face the new reality of the oversupply of data, when the decision-makers are constrained to cope with plenty of information and abundance of possibilities with the higher degree of uncertainty. The role of education and of teaching in this context is deeply reoriented from giving facts to giving competences to act.

1.1. Less influential constraints of physical distance and higher impact of temporary dimension

The higher speed of making choices and the mobility of financial and human capital determine the new context for the economics as a science which studies human behaviour and relationship about scarcity. The problem of scarce resources constrains agents to make choice among alternatives, but in the situation of abundant data the knowledge and information are scarce resources only with many strict conditions: the data are to be pertinent, up-to-date, comfortable to treat, and the user should be able to use them to achieve her or his goals. The scarcity as the key basic feature of economic science has changed in nature – the time became a determinant that is a core element of the value of information and knowledge.

The knowledge is a resource that is expensive to produce and cheap (almost free) to reproduce, the fixed costs of creation are huge, but once a knowledge is mastered, the further use of the information, competence or technology requires an incomparable less investment. The use of the knowledge already created permits to imply the fixed costs equal to zero and to apply the price very close to marginal (variable) costs. The profit in this situation is produced by the flexibility, wide bulk of choices and speed of consumers' needs satisfaction (the "integrators" services).

1.2. Economic and management competencies

The learning organisation (Argyris & Schön, 1978) and the fifth discipline (Senge, 1990) are the concepts that were introduced on the basis of deep empirical studies of organisational functioning and of analysis of the application of the post-modern theories of management.

The double loop of learning and the reflexivity as the managerial approaches create the significant part of the new education model, teaching tools and studied content, especially, for the managers' instruction and for competencies' development. The faster technologies' progress is, the more significant becomes the ability to study, to analyze, to learn and to change the competence to make decisions in non-standard situations and to create non-standard solutions for a standard situation.

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1.3. Academic milieu for knowledge creation and dissemination

The new information technologies and remote learning methods have huge perspectives in this field due to the faster possibilities to acquire the experience of marking decisions within specific contexts and situations. In the core of the management education, the employers put the competence to solve the specific problems in an unexpected context and to seek new solutions within the standard circumstances. The innovative and creative competences play a significant role for the up-to-date management skills.

The academic institutions' role is changed from transfer of information to the creation of the competences of life-long learning, the ability to refuse old methods of solving tasks and to invent or adapt new solutions, to bear risks and to take responsibility for the decisions made and to anticipate the consequences. The labor market already represents the need for autonomy and entrepreneurship as the ability to act as an entrepreneur inside the organizational structure ("intrapreneurship"). It takes into account the fact that the internal processes and relationship, the entrepreneurial audacity and competitive spirit are to be combined with the capacity to build trust and to enhance team working, cross-cultural co-operation with the corporate "citizenship". The academic milieu is a "sandbox" to train this blending of contradictory skills and competences.

2. Problem Statement

The academic institutions are passing through the specific evolution. The traditional functional role of the transfer of knowledge is replaced by the systemic societal role of the cultural transmission. According the functional definition of culture as a system of specific adaptation mechanisms of a humans' group, the transmission of culture can be analyzed as a very well known role of Universities. The culture of scientific research was in the heart of the university' life within the middle age. Now the culture of learning represents the most significant part of academic life; the double loop, the spiral of knowledge and the methods of inventive problem solving are the central elements of the university' utility for the post-modern society. This reasoning allows one to return to the intentional part of the definition of knowledge as a kind of reality reflection which permits to gain benefits.

2.1. Value creation as a concern of economy

The economic subsystem is intended to solve the functional tasks of satisfying human needs within a societal system. The culture permits to transfer the achievements of the previous generations to the next ones through the collective activity of the group, including the social institutions. The collaborative strategies of business are deeply described by the Aristotle (384-322 b.c.) definition of a man as a social and political animal which was mentioned as a reason of the Greek cities (polis): "a city is a natural production, and that man is naturally a political animal… man is a more social animal than the bees, or any of the herding cattle" (Aristotle, 1912, p. 4). The division of labor, specialization and cooperation through the collaborative approach were helpful for the effective realization of these tasks, and until today, the possibility to get advantages from the diversity of people and groups involved into economic processes increases the total productivity at the level of a firm or region, or on a global scale.

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2.2. Value creation chain as a management problem

For corporate governance, diversity of individual talents of the personalities, implicated into the organizational business processes, is the source of the performance (Argyris & Schön, 1974). For the business, the people and the competencies are useful, if the participants are able to collaborate efficiently – the case of the Hubble telescope mirror is a famous evidence of the need for wise governance of personalities and teams working for the common project (Pellerin, 2009; Capers & Lipton, 1993).

2.3. Business strategies within the innovative growth and new challenges for higher education

The key element of a business-model success is the leadership in innovations' rivalry. The establishing of criteria and regulatory mechanisms (such as the decimal numeral system, the English language or OS from Microsoft) permit to assure a market primacy and special competitive advantage, the qwerty-effect or path-dependence. E.g., the company DJI that created the accessible multi-copters is one of the authors of the multi-copters flights' regulation, the rules themselves and the software to manage and to renew and improve the rules. The paradigm of the economic success is changed from orientation to resources scarcity and search for methods to increase the productivity and effectiveness of management known as efficiency-driven growth (Tan, 2004) towards the necessity to be the first in a narrow niche or a new field. The concept of a blue ocean (Kim & Mauborgne, 2004) reflects the temporary monopoly, free from competitors, based on the constant innovation.

3. Research Questions

Customers compare a product or service' price (measure of costs) with the value obtained from the product or service' use. If the "costs" are quite easy to manage within the industry 4.0. approach with digitalized management and robotized mass manufacturing or individualised 3D printing, the most influential factor is the value that is created by the company for the customer. The competences and skills to improve this value are the core question for the professional education.

3.1. Knowledge-driven economy and information society

The production of knowledge meets the curiosity needs of humans; the transfer of knowledge is the subject of the educational system and of intellectual property rights' market. The use of the knowledge is the "last" stage of the classical chain of value creation, and this element represents key methodological concerns of (a) a dilemma between the protection of intangible assets and the open public access to the knowledge created, (b) an ethical or humanitarian question of the knowledge use for the "correct" purposes.

The profit-driven business-models raise the problem of the social responsibility in the vital form of well-being based on the ecological approach. This approach is to be applied not only to the environmental issues of nature around, but also to the careful treatment of the human nature, taking into account the "happiness", the psychological and social well-being. The cultural transmission in the higher educational system should create this ability to cope with the new world of the abundant information.

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3.2. Industry 4.0' division of labor

The methodological question for economic research of knowledge concerns the interpretation of knowledge as an input, internal process and output within the societal system and the economic subsystem. The virtual or augmented realities are based on the symbolic worlds already existing inside the social mentality and culture in personal conscience. The design of a brand as a tool for personal self-identity creation relies on the symbolic universes and on the biological processes of human beings.

The artificial intelligence (AI) is still not efficient in accomplishing two tasks of competitive companies management – (a) to interest and motivate participants involved within team building and (b) to create a symbolic world (a "religion") to self-identifying customers within the relationship building.

The humans' role in the connected manufacturing within the Industry 4.0 will be related to these two key components of the efficient approach to innovative growth. The entertainment sector within the approach of experience economy (Pine & Gilmore, 1999) and the use of the gamification for routine tasks within economic activity (even, involving the interest of open public audience) represent two facets of the development of specific skills for the functions, where people can not be replaced by a machine.

3.3. The h2h competencies within industry 4.0

The third competitive advantage is related to the capability of a business to create a special link with the customers based on the miracle of human communication with the diversity and richness of the real personal contacts, including all the channels of perception and the human reactions. The affective component and emotional intelligence play an important role in sectors of the service with high impact on caring human life, such as medicine, nursery, baby-sitting, children and family' care, the sectors, where the trust to the people concerned is the key element of the successful development.

The integrated product-service complex set meets two requirements – the optimisation of choices (through different mechanisms of ratings, multi-criteria filtration, intelligent search engines, etc.) and the possibility to avoid the necessity to become bogged down into human relationship and communication. The neuron technologies-based call-centres (Leontieva & Ababkova, 2016) and human interfaces, using the AI, represent a way to safe funds and significantly decrease the fixed costs. But for other companies, the use of non-automated human labour presents a competitive advantage, the impression left by the quality of the time passed. The mood created and feelings also are an important competitive advantage.

4. Purpose of the Study

The academic institutions are to define the tendencies of their role in the society and to adapt the strategies to the requirements of the students, scholars and employers.

4.1. The content to be provided by academic institutions

The intentional vision of the knowledge transferred through the higher education institutions leads to the pragmatic understanding of the criteria of the education' quality. The professional skills and the abilities of graduates includes the capabilities to fulfil the tasks within their vocation and outside the

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initial field of profession. If the knowledge is a mean to achieve goals, the educational system needs to create the competencies of change, of information search and study.

4.2. The integration of the research and training into economic activity

The knowledge creation (invention and implementation of new technologies and new approaches) and transfer can be incorporated into the business and professional activity with the methods of blending the laboratory learning and teaching in classrooms (companies' representatives' master-classes, etc.) and the internships at enterprises. The change of the list of professions will need the regular change of syllabuses of the universities' educational program (Alexankov, Surygin & Kalmykova, 2012).

The design of a new form of the professional graduating approach can be based on the additive principle of a combination of classroom activity with labs research and with the accumulation of a free choice of courses that seem to be useful for students' individual learning path. The purpose of the study is to elaborate an approach to graduating for such educational regime on the additive basis.

5. Research Methods

This theoretical research is based on the structuring of conceptual studies and the analysis of documents in the field of the analysis of the economic and social impact of disruptive technologies and the anticipations for the industry 4.0. The foresight approach in the education planning needs the correct arguments to be legitimized for educational graduating within the new economic system.

6. Findings

The understanding of the industry 4.0' requirements toward the educational process as a system of transfer of knowledge allows one to point out the following 4 components:

- integration of research, training and business institutions,
- the emphasized regulatory evolution for the innovative specific competences,
- the public and private cooperation for the human capital improvement
- the search for new forms of the knowledge use.

6.1. Business networks and organisational integration for learning

The intramural R&D intensive industries (ICT, pharmaceutical sector) and the high-tech manufacturing and services represent only a narrow part of the knowledge intensity to take into account. The sectors with a widespread industrial wisdom can also include the knowledge-intensive and innovative industries (Smith, 2000), e.g., agricultural production at aerofarms or arctic offshore oil and gas drilling.

Medieval guilds, the French model of "compagnonnage" (professional training through travel from one workshop to another, form one master to another) and the MBA as a XX century system of the managerial skills exchange, represent in their deep roots the similar principle of the experience accumulation through the study of many real cases and multiple personal contacts. The clustering experience demonstrates that creation of an integrated system generates the critical mass of competences.

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6.2. Regulation of the process of innovation growth and progress of technologies

The transition from resource-based (Solow, 1978) and factor-driven (Abramovitz & David, 1996) economy toward the innovation-driven (Koh, 2005) economic model is based on the technological changes and the capacity of nations, firms or individuals to be in advance. The resulted leadership as a targeted goal represents, in fact, the carefully designed process of innovative competencies fostered inside the companies and research labs and in the culture as a sophisticated mechanism of the individuals' behaviour regulation, through the values' scale and the social sanctioning.

The key element of a business-model success is the leadership in innovations' rivalry. The establishing of criteria and regulatory mechanisms (such as the decimal numeral system, the English language or OS from Microsoft) permit to assure a market primacy and special competitive advantage, the qwerty-effect or path-dependence (e.g., the company producing mass multi-copters DJI is among the authors of the multi-copters flights' regulation). The paradigm of the economic success is changed from orientation to resources scarcity and search for methods to increase the productivity and effectiveness of management known as efficiency-driven growth (Tan, 2004) towards the necessity to be the first in a narrow niche or a new field. The concept of a blue ocean (Kim & Mauborgne, 2004) reflects the temporary monopoly, free from competitors, based on the constant innovation.

The approach of Industry 4.0 deepens this analysis with the networking and connectedness effect (UNIDO, 2015), including the German governmental project (BMBF, 2016) and the Japanese Connected Factories programme for monodzukuri as a specific Japanese harmonious sustainable manufacturing style (Toyota's Monozukuri, 2012) with a highest quality and unique competence as a regulatory mechanism.

6.3. Human capital development and investment to the infrastructure

The two essential components of the human capital include the physical health and the intellectual development. The human capital development needs the key elements of the services to be provided, including the everyday life infrastructure for basic needs (the quality of environment, the ecological situation, the healthcare system, the choice of food and entertainment services, etc) and the long-term needs (insurance services, family life, educational institutions for children and medical services for elder members of families). These requirements for infrastructure include also the communicative technologies, the access to museums and to labs, etc. E.g., the limitation for the wi-fi network expansion prevents the high-tech industries development, because the youngest and the most mobile people will refuse to work or to live in the local environment that is not able to assure a fast and smart connection to the internet as a possibility of getting knowledge and information.

6.4. Dilemma of intellectual property protection and the public access to the domain of information, technologies, arts and knowledge

The dilemma related to the transfer of technologies represents the choice between a free knowledge exchange that explains the successful evolution of clusters and techno-parks (within "Silicon valleys", the transfer of knowledge helps to enrich the initial information and competence), and a limitation of the access to the knowledge produced within a system of intellectual property protection (compensation of fixed costs with the system of royalties, franchise, licensing etc.).

The regulatory approaches are to be improved on the basis of a compromise or of differentiation of regulatory tools. A set of criteria is to be determined to classify agents, contents or purposes to assure or to limit the access (i.e., free or discounted access for education, research organisms and for national small business, prohibition or limitation for other agents). The open free access to a pre-determined volume of knowledge or data is not sufficient for actual business, and human capital will migrate towards the regions or spaces (urbanised places, industrial clusters, cities' districts) equipped with the infrastructure.

7. Conclusion

The digital economy, the technologies of information processing and the technical progress of robotic equipment and 3D printing demonstrate the exclusive human role within the economic growth and the specific skills to form for successful career opportunities. There are the competences of understanding and of feeling, the contribution to the sense and meaning added to the Universe of data and knowledge.

The activity at the heart of the professional education is to demonstrate the model of learning and analyzing developments and complicated questions of the effective ways to communicate and to create new visions and ways, to engage the inspiration and daring. The teacher is supposed to draw the boundaries of thought and action and, at the same time, ways to transform the map of the social reality.

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