CONCEPTUAL FRAMEWORK TO STUDY THE ROLE OF HUMAN FACTOR IN A DIGITAL MANUFACTURING ENVIRONMENT

КОНЦЕПТУАЛНА РАМКА ЗА ИЗСЛЕДВАНЕ НА РОЛЯТА НА ЧОВЕШКИЯТ ФАКТОР В ДИГИТАЛНА ПРОИЗВОДСТВЕНА СРЕДА

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Abstract: *Nowadays, the dynamics of technologies development, as well as continuously growing customers' requirements, put industrial enterprises from around the world before the necessity of rethinking old strategies and building new dynamic business models, in order to successfully continue operating in today's conditions of a highly competent market environment. The digitalization takes a key position in this new scenario, where modern industrial enterprises should fit. Digital technologies, as well as the opportunities they create, are the main moving power, which enterprises should stake upon, to successfully raise their own efficiency. One of the biggest threats caused by the digital transformation of operations is for the people to be replaced by the machines. The present paper offers a conceptual framework of a methodology for investigating the role of human factor in a digital manufacturing environment.*

***KEYWORDS**: HUMAN FACTOR, INDUSTRY 4.0, DIGITALIZATION, SMART MANUFACTURING, DIGITAL COMPETENCES*

1. Introduction

The digital transformation, as a part of the Fourth Industrial Revolution (Industry 4.0), faces the industrial enterprises to the need for a change in the organizing and managing their operations system [1,2,3,4,5,6,7,8,9,10]. The driving powers of this change are Internet of Things (IoT), Internet of Services, Big Data, Cloud Technologies, Smart Objects etc. and they are the ones that transform working environment of the industrial. The people should be replaced by automated systems and robots in performing the routine and hard-work operations. This way, the flexibility and productivity of the operations system will be improved [11,12,13,14]. Namely, this exchange of people with machines/ robots is considered to be one of the biggest threats caused by Industry 4.0. According to [15] during the period 2018 until 2020, 10% to 15% of the jobs are expected to fade away, which is a change much more serious than decades before – when, as a consequence of automation, 4% to 9% of jobs only have been dropped out. A resent research [15] shows that on an average of 71% of the total working hours in the different business branches are covered by people, and 29% – by robots. It is expected that by 2022 this average values will change to 58% for the workers, and 42% – for the machines accordingly [15]. In addition, according to [15], 62% of the tasks related to information search, processing and transmitting, are expected to be mainly assigned to and performed by the machines. Apparently, such fears have also existed during previous three industrial revolutions, which have caused perturbations of the labor market too, as well as emerging new jobs, professions and requirements for new qualifications.

Of course, the manifestation of this threat on a large scale now is caused mainly by the existence and application of the artificial intelligence. However, to reach the efficiency required, the artificial intelligence needs to be combined with the appropriate industrial experience, as well as the physical model of the machines themselves. That is, the role of the human factor should not be underestimated and neglected. It could be summarized that, as a result of the digitalization, a considerable change is expected in the field of jobs "distribution" among the people and the machines, having in mind following peculiarities:

(1) *Machines/robots acquire an increasing importance in running the operations system of the enterprise, as well as they become more and more autonomous (decision making at the lowest level) in performing tasks/operations they are assigned to;*

(2) *The place and the contribution of the human factor in the operations system is profoundly changed;*

(3) *The human-machine relationship goes to a new, "intelligent level".*

Accepting the technologies as a threat for the labor is becoming a key cultural issue, since inner opposition could be strong enough to vastly postpone putting operations into effect to the requirements of Industry 4.0. Industrial enterprises should elaborate a strategy to assist the process of digitalization in a way, avoiding stress for the working force.

It is important to note that digital transformation itself enables specific inherent human abilities to show up, such as *creativity, originality/innovation, initiative, agility, analytical abilities, criticism, abilities to intuitively solve complex problems* etc.

The abilities to convince and negotiate become more and more important. The emotional intelligence, leadership and social influence are incidental to the humans' qualities, and they are expected to be more deeply engaged in the professional areas since by now they could not be imposed upon the machines.

The above mentioned arguments require a research on the requirements laid by the digitalization over the working forces, and the way of their adaptation to the new environment.

The purpose of the present paper is to offer a conceptual framework for investigating the role and the place of the human factor in the process of transition to this new manufacturing model based on an intensive utilization of the new digital technologies.

2. Methodology Framework

An empirical study of the role of human factor in the conditions of the digital environment should be performed in two stages, as shown on Figure 1 [16,17,18]:

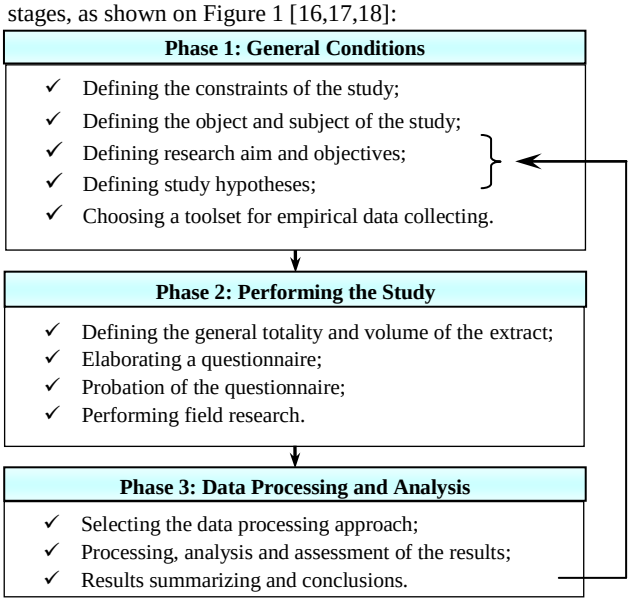

***Figure 1.** Common research methodology*

Phase 1: General Conditions

✓ ***Defining Study Constraints***

The study is intended to be hold in machine-building enterprises. In order to narrow the focus of the study, a special attention will be paid on investigating the issues concerning system design, performance and management of the operations in a digital environment conditions and resulting from it peculiarities affecting the working force.

✓ ***Defining the Object and Subject of the Study***

The ***object of the study*** is aimed to be the personnel responsible for managing and serving manufacturing operations, performed in the machine-building enterprises, such as production/ operations managers, technologists, designers, machine operators etc.

Directly connected with the object is the ***subject of the study***, namely – the issues arising from the role, place and requirements to the human factor in the conditions of a digital manufacturing environment.

Note: The decision to limit the study to investigate work force in the production/operations system of the enterprise is based on the fact that this system is affected to the greatest extent by the digital transformation and, as a consequence – its personnel.

✓ ***Defining research aim and objectives***

By the present study, the author is aiming the following goals:

- *To study the personnel's mood to the digitalization of manufacturing;*
- *To study the opportunities to lower the level of the risk for personnel's resistance to the digitalization of manufacturing;*
- *To investigate the factors enabling personnel's adaptation to the requirements of digitalization of manufacturing;*
- *To investigate the personnel's contribution in the process of digitalization of manufacturing;*
- *To investigate the human-machine relationship and its importance for an effective and efficient running of the operations system in a digital environment.*

✓ ***Defining Study Hypotheses***

With the present study, it is expected one of the following hypotheses to be confirmed or rejected:

- ***Hypothesis 1:*** *„The effectiveness of the digital manufacturing system depends on the efficiency of the man-machine interaction";*
- ***Hypothesis 2:*** *„The high degree of manufacturing processes digitalization requires a change in the human resource management strategy in order to achieve effective adaptation to the new manufacturing environment ".*

✓ ***Choosing a Toolset for Empirical Data Collecting***

For the purposes of the study, it would be appropriate a questionnaire to be used that is structured in a way to help achieving study goals.

Phase 2: Performing the Study

✓ ***Defining General Totality and Volume of the Extract***

Defining the general totality of respondents and the volume of the extract is based on the well-known methods of mathematical statistics [19].

✓ ***Elaborating a Questionnaire***

This chapter is going to ensure opportunity for a short presentation of the following groups of information:

Group A: Common presentation of the enterprise

Here, a short presentation of the factory under study is made – enterprise name, branch and performed activities, registration form etc.

Group B: Information about specifics of Industry 4.0

In this section some information is put about the need for knowing requirements, characteristics, technologies etc. that are prerequisites for achieving an effective manufacturing digitalization.

Group C: Information about manufacturing/operations system of the enterprise functioning

Here, a detailed information is included about technological infrastructure built, as well as to what extend any digitalization is achieved.

Group D: Information about personnel's readiness to accept the changes raised by the trend of manufacturing processes digitalization

This section provides information about personnel's perception for the changes and the extent to which it is ready for them. Also, it is important to provide information here about personnel's understanding about the need and effectiveness of the changes that are caused by the digitalization. This will enable an assessment of the risk for personnel's resistance to the changes.

As a part of this section, it is foreseen some instructions to the interviewer to be elaborated, as well as instructions to the respondents.

✓ ***Probation of the Questionnaire***

The methodology advises a pilot study to be performed, aimed at testing the questionnaire, in order to make sure that the quality of the main field research will be guaranteed.

✓ ***Performing Field Research***

During interviews, the instructions elaborated in the previous sections have to be fulfilled correctly, and respondents should also be introduced in general about the aims of the study.

Phase 3: Data Processing and Analysis

✓ ***Selecting the Data Processing Approach***

To proceed and interpret the information gathered, methods from the mathematical statistics will be used, such as dispersion analysis, regression analysis, descriptive analysis etc., according to the situation specifics.

✓ ***Processing, Analysis and Assessment of the Results***

Тук следва получените резултати да бъдат съпоставени с поставените изследователски цели, а също така да се потвърди или отхвърли верността на дефинираните хипотези.

✓ ***Results Summarizing and Conclusions***

Here, the results of the study will be systemized, integrated and presented in a common strategy for a successful transition to a digital manufacturing through a collaboration by the personnel's side.

3. Conclusion

Instead of considering technologies invasion as a threat and replacement of human work force, it should rather be observed as a means enabling people to focus on these particular operations that add value.

Eventually, the man and the machine are not put on both sides of the barricade. Therefore, if both enterprises and workers get use of their chances, the co-existence of autonomous systems and people could initiate a new era in the world of labor, and the comprehensive approach to the planning, training and improving the work force is the key to the effective management and development of the trend to the digitalization.

4. References

[1]. Андреев О. (2013), Съвременни системи за производствен и операционен мениджмънт, Учебник, Софтрейд, ISBN 978-954-334-150-4, 167;

[2]. Андреев О. и Пенева Г. (2018), Методически подход за изследване на възможностите за внедряване на

„Индустрия 4.0“ в българските индустриални предприятия, XVI международна научна конференция “Мениджмънт и инженеринг’ 18”, стр. 739-745 , ISSN 1310-3946;

[3]. Andreev O. & Peneva G. (2018), Problems Concerning Operations System of the Enterprise in the Context of Industry 4.0, X International Scientific Conference “E-Governance & E-Communications”, pp. 165-170, ISSN 2534-8523;

[4]. Koleva N. & Andreev O. (2018), Aspects of Training in the Field of Operations Management with Respect to Industry 4.0, International conference on High Technology for Sustainable Development, IEEE, pp.1-3, DOI: 10.1109/HiTech.2018.8566581;

[5]. Koleva, N. (2018), Industry 4.0’s Opportunities and Challenges for Production Engineering and Management, International Scientific Journal Innovations, issue 1, pp. 17-18, ISSN 1314-8907;

[6]. Pereira A. C. & Romero F. (2017) A review of meanings and the implications of the industry 4.0 concept, Manufacturing Engineering Society International Conference (MESIC), 28-30 June, Spain, pp. 1206-1214.

[7]. Zhou K., Liu T. & Zhou L. (2016). Industry 4.0: Towards Future Industrial Opportunities and Challenges, International Conference on Fuzzy Systems and Knowledge Discovery, pp.2147-2152.

[8]. Daskalova M. & Angelova J. (2015), Control Environment Influence on the Realization of a Company Strategy, XIII International Scientific Conference “Management and Engineering’15”, 21-24 June, ISNN 1310-3946; ISNN 1314-6327, pp. 229-238;

[9]. Николов Б. (2011), Съвременният етап на управление на МСП в България – управлението на риска като част от системата за управление VIII Международен конгрес „Машини, технологии, материали”, 19-21 Септември, Варна, том 3 „Симпозиуми: Ергономия и дизайн индустриална информатика, зъбни предавки, мениджмънт”, стр.183-186, ISSN 1310-3946;

[10]. Николов Б. (2016), Управление на надеждността и техногенния риск в производствените и операционните системи, ИК „Кинг“, ISSN 978-954-9518-87-0;

[11]. Ilieva, R., M. Nikolov. Robotic Process Automation Beyond Human Perception. Proceedings of the XVIth International Conference “Management and Engineering’18”, vol. II, June 24-27, 2018, Sozopol, ISSN 1310-3946, pp.714-719.

[12]. Николов Б. (2009), Промените и тяхното управление – ключов фактор за успешното функциониране на индустриалните предприятия, Списание „Машиностроителна техника и технология”, ТО на НТС-Варна, ТУ- Варна, бр.2, стр. 8-11, ISSN 1312-0859;

[13]. Brettel M., Friederichsen N., Keller M. & Rosenberg M. (2014). How virtualization, decentralization and network building change the manufacturing landscape: an Industry 4.0 Perspective, International Journal of Information and Communication Engineering, Vol: 8, No1, pp. 37-44.

[14]. Shamin S., Yu H., Cang S & Li Y. (2016) Management approaches for Industry 4.0: A human resource management presprctive. IEEE Congress on Evolutionary Computation (CEC), DOI: 10.1109/CEC.2016.7748365, pp. 5309-5316.

[15]. World Economic Forum White Paper Digital Transformation of Industries: In collaboration with Accenture Digital Enterprise (2016), Available online at http://reports.weforum.org/digitaltransformation-of-industries/wp-content/blogs.dir/94/mp/files/pages/files/digital-enterprisenarrative-final-january-2016.pdf

[16]. Александрова М., (2012). Методи за изследване в бизнеса. Издателски комплекс - УНСС.

[17]. Недялков, А. & Найденов, Н. (2012). Изследване на необходимостта от изженерно-технически услуги за малките и средни предприятия, научна студия, Авангард принт, 36 с., ISBN 978-954-337-171-6.

[18]. Недялков, А. (2009). Методически аспекти при изследването на клиентите, Научни трудове на русенси университет, том 48, серия 5.1, стр. 13-18

[19]. Zikmund, W. (2002). Business Research Methods. 7th ed, Thomson/South-Western.