General technical personnel preparation using studying and production union of universities

A V Gurjanov\textsuperscript{1}, D A Zakoldaev\textsuperscript{2}, A V Shukalov\textsuperscript{2} and I O Zharinov\textsuperscript{2}

\begin{itemize}
\item \textsuperscript{1} Director, Stock Company «Experimental Design Bureau «Electroavtomatika» named after P A Yefimov, 40, Marshala Govorova St., Saint Petersburg, 198095, Russia
\item \textsuperscript{2} Faculty of Information Security and Computer Technologies, ITMO University, 49, Kronverksky Av., Saint Petersburg, 197101, Russia
\end{itemize}

E-mail: 131926@itmo.ru

Abstract. Changing labor conditions and occupation content in the Industry 4.0 companies led today to the personnel qualification requirements reconsideration. To prepare new and to re-shape the existing industry specialists must be done in smart factories, which are integrated with studying and production unions of universities. A smart factory extended model provides the personnel acquiring of the discrete production project activity practical experience. The studying and production union of universities education environment may help students to realize themselves in an artful way and improve the personnel acquisition of the intellectual system application knowledge and skills realized as plant modules, which are identical to the real production equipment. The education environment provides for students the real modules of cross-platform working stations and tools, which let students actively influence the discrete production operation and economic indications. The skills honing in production training facilities in safe technological environment is the Industry 4.0 ideology legacy to the Education 4.0. There is a scheme of science and production union of universities infrastructure, which is used to study special disciplines of the ply-technical base.

1. Introduction

The branch companies mundane necessities in professional specialists are viewed as the Industry 4.0 net production and makes it actual to consolidate the tutors, designers and manufacturers into unions which function with the principles of a studying and production union of universities (SPUU), where an SPUU is the Industry 4.0 education services provider which satisfies the labor market with workers of different specialties and similar occupation groups which are necessary for a discrete production \cite{1, 2}.

To prepare a competitive staff from the education point of view is a strategic cadres planning element, which is to develop in students the application skills of a competitive job, which are necessary to complete the complicated inter-disciplinary tasks \cite{3}. To re-organize the classical model of professional education according to the nowadays industry requirements and is based with close educational process involvement of persons and electronic systems united as an interactive research platform \cite{4, 5}.

The studying and production site supports the personnel education model with the following practical advantages \cite{6, 7}:

- the specialist target preparation with new industrial occupation groups which sometimes have a super narrow specialty and which substitute the manual and semi-automatic labor;
• theoretical and practical aspects of an Industry 4.0 discrete production which they receive directly in an industrial company including the cyber-physical systems exploitation experience and basic work principles in a protected production environment;
• the application of educational consulting technologies in a remote interaction of students and tutors granted by an academic society from a number of leading specialists which apply digitalizing educational cases in the industrial automatizing;
• the discrete production machine environment application to construct the studying classes and specialized stands of research laboratories which let students improve the ways how the future workers could complete their labor functions and actions;
• the inter-disciplinary approach to form the worker competences, which requires from the educational model to use unique studying products reflected in studying materials and providing the young specialist culture establishment and other.

The specialist preparation educational process industrial segment participation is a factor to give a stimulus to the population employment level and appearing in developing countries of new technological way, which may catch the Industry 4.0 actual tendencies [8, 9]. The SPUU format helps to integrate cases from industrial practitioners into the educational program models because of which the Education 4.0 is enriched with new production education methods with a higher efficiency for the company (the qualified personnel necessity satisfaction) [10, 11].

The step by step specialist preparation integrated technologies develop the Education 4.0 module system which expands the classical educational themes with new didactic material oriented for innovations [12, 13]. The practical steps to apply new working and organizing tutorial models into the specialists preparation could be done as the part of educational program completion attuned with two-way connection (tutor-student) based on a self-controlling system principles [14, 15].

2. The SPUU infrastructure
A SPUU is a smart factory miniature version (a mini-plant) which in their organizing functions is for practical student grasping of the discrete production principles. A SPUU realizes the company production personnel inter-disciplinary education without separating them from their jobs who wants to grasp new occupation or with old occupation knowledge. The SPUU preparation directions are engineering occupations necessary for the company digital transformation or to service the production industrial equipment, where the digitalizing is of high efficiency. The SPUU infrastructure scheme is given in figure 1.

The SPUU includes the following full-functioning components:
• the industrial automatizing plant modules represented as cyber-physical solutions integrated as the production equipment;
• the cross-platform working stations, which are equivalent of real plants conveyor lines designed as industrial systems identical to the production equipment;
• the laboratory replica and stands with integrated modelling instruments and production processes characteristics analysis, which clearly demonstrate the students the routine technical operations automatizing principles.

The SPUU components unification into different architectural layers let create a real production environment being controlled by a student, which emulate the functioning of mechanical and electronic technologies and cyber-physical systems. The hierarchy and decentralized nets of physical and virtual equipment engaged into the education process are represented as:
• a horizontal net unites plant modules, stands and replicas into third-dimension automatized measuring, informative and controlling production systems with different scenarios of application;
• a vertical net provides continuous interaction of cyber-machines, which have in their SPUU virtual environment some unique identifiers through the production interfaces which could be programmed.
To control a discrete production through the programmable solutions is the education process secure base where the Industry 4.0 cyber-technology students are immersed which is an entertaining practical (interactive) individual or group lesson dedicated to study one of many educational themes. The assembly units tide intellectual control may create a plurality of cross-platform stations configurations in each of which the practitioner may evaluate the isolated plant modules influence on the discrete production operational indications. The production orders prioritizing and plant infrastructure load balancing become in an SPUU a practical project exercise, which helps students to understand better the definitions and appendices of cyber-physical systems with the difficulty level that could be grasped.

3. The SPUU educational aspects
The SPUU appearance as an educational system component corresponds to the industry increasing defiance for qualified engineer specialties working force demand necessary for a discrete production. The production company economic growth classical points are traditionally related to search and employment of ready specialist who has the necessary competences to complete a given number of given functions. But the Industry 4.0 discrete production professional cadres lack problem do not let for production companies fully refill the vacancies available with prepared specialists.

The modern technological progress dynamics is so quick that education companies cannot satisfy the qualified cadres production segment increasing demand. Chasing after the innovations the production companies will prevail if they are ready to invest their own resources into the education (re-preparation) of their own personnel.

The industry participation in professional orientation activity with subsequent personnel training using the SPUU resources may make a system of the discrete production gathered knowledge and significantly expand the theory and practice of the existing educational programs. The discrete production aspects reflected in SPUU as some special practical courses which provide new knowledge of educational situations for students when grasped and those imitate in maximum the real industry work conditions.

The SPUU format integrated in a smart factory let realize the personnel training as a group (in the level of a brigade) and also in individual way. Oriented for industry practical trainings is the base of interesting study projects where the experienced specialists and tutors including the masters of

![Diagram](image_url)
production training pay a lot of attention to study closely the working situations which may arise after the students actions monitoring or events generated by the SPUU infrastructure.

The SPUU tools which let the personnel improve their knowledge and skills in the following typical production situations:

- the production processes monitoring task solution in the technological equipment environment which is a part of a cross-platform working station with the item manufacturing complicity level being regulated;
- a complex modelling and monitoring of the one item manufacturing production operations sequences using several technologies which is the Industry 4.0 core;
- the item bunch automatic manufacturing assembly units tide video control which is a single type of an industrial product;
- the virtual test in the field and technological maintenance procedures completion for basic and applicable plant modules using the cyber-physical systems graphical coding elements;
- the industrial company efficiency economic growth points finding out after a research of the production functions division module principles when the added value items being manufactured completed tides are created;
- the protected education environment any complexity level item being manufactured virtual prototyping supporting the plant modules remote control server and other.

4. Conclusion

The SPUU realizes a general technical industrial company personnel educational preparation after which the students receive practical experience how to apply technologies, which influence the discrete production operation and economic indications. Student knowledge and skills honing is done with a mentor from the plant modules specialists (the existing industrial equipment samples), which helps the personnel to acquire the work occupation content, which correspond the company qualification necessities.

The real production process imitation is done in an education environment with a poly technical base to guarantee the personnel safe working conditions during the studying. Oriented for practice studying lessons format lets work out with the students a lot of themes individually or in teams (brigades) for which the preparation is done. The labor studying using SPUU resources provides the education process acceptability within which brigades forming is permitted for different stages of the education program.

The educational lessons standards improving with the SPUU is done by implementing the student self-control principle in the education technologies and application of the methodical literature library funds enriched with actual industrial knowledge. Elective ways of personnel preparation may make settings of an education program with differentiated education period and qualification levels within each of which the basic norms congregation made by students is installed.

Application of real plant modules into education process may increase the personnel studying efficiency and develop in students labor skills in selected occupations related to a discrete production. The personnel professional orientation and their participation into production projects of the future let the SPUU take their honorable place in the Education 4.0 system as an independent student platform.

In the forthcoming aging of the Industry 4.0 labor market population will be in a stagnation state not just because of their specialist knowledge moral aging but also because of young working force adapted to grasp new professional competences. To avoid job loss by the industrial companies honorable cadres they need to put themselves into the SPUU educational environment using in their educational programs the tools, which get the practical tasks more complicated little by little dedicated to a discrete production different aspects.

Acknowledgments

This article was prepared with the Financial support of the Ministry of Science and Higher Education of the Russian Federation under the agreement No 075-15-2019-1707 from 22.11.2019 (identifier RFMEFI60519X0189, internal number 05.605.21.0189).
References
[1] Martinez P, Vargas-Martinez A, Roman-Flores A and Ahmad R 2020 Procedia manufacturing 45 84-9
[2] Li F, Yang J, Wang J, Li S and Zheng L 2019 Procedia manufacturing 31 343-8
[3] McHauser L, Schmitz C, Hammer M 2020 Procedia manufacturing 45 246-52
[4] Nelson S X, Khumbulani M, Innocent R B, Aziz C, Thabiso M, Sinenhlanhla N and Thierry Y 2020 Procedia manufacturing 45 386-91
[5] Schallock B, Rybski C, Jochem R and Kohl H 2018 Procedia manufacturing 23 27-32
[6] Buth L, Blume S, Posselt G and Hermann C 2018 Procedia manufacturing 23 171-6
[7] Centea D, Singh I, Elbestawi M 2019 Procedia manufacturing 31 109-15
[8] Wienbruch T, Leineweber S, Kreimeier D and Kuhlenkotter B 2018 Procedia manufacturing 23 141-6
[9] Jooste J L, Louw L, Leipzig K, Conradie P D, Asekun O O, Lucke D and Hagedorn-Hansen D 2020 Procedia manufacturing 45 379-85
[10] Vijayan K K, Mork O J 2020 Procedia manufacturing 45 411-6
[11] Sadaj E A, Hulla M, Ramsauer C 2020 Procedia manufacturing 45 60-5
[12] Teichmann M, Ullrich A and Gronau N 2019 Procedia manufacturing 31 72-8
[13] Zhang W, Cai W, Min J, Fleischer J, Ehrmann C, Prinz C and Kreimeier D 2020 Procedia manufacturing 45 66-71
[14] Herstatter P, Wildbolz T, Hulla M and Ramsauer C 2020 Procedia manufacturing 45 289-94
[15] Mourtzis D, Vlachou E, Dimitrakopoulos G and Zogopoulos V 2018 Procedia manufacturing 23 129-34