Innovative approach to training industry 4.0 experts

Marina Savelyeva and Natalia Shumakova
Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037 Russian Federation

E-mail: mvsavelyeva12@gmail.com

Abstract. The research concerns the changing requirements to a new generation of experts demanded by Industry 4.0. Rapid technological development of the enterprises, digitalization of their processes galvanize the universities to adapt their approaches to both students, training technology and quality control management. Moreover, we compared manufacturing process with the educational one, analyzing the possibilities of the currently developed teaching technology to comply with the enterprises’ demands.

1. Industry 4.0 experts’ development
In order to transfer successfully towards knowledge-based economies, industries need to formulate necessary sets of skills for future and current workforce to the Universities to develop them. The idea of working process automation in this connection is a crucial one. According to a recent report by McKinsey Global Institute derived from evaluations of 2000 work activities across 800 occupations, by adapting only the well-established technologies almost 5% of all occupations can be fully automated while 60% of all occupations have at least 30% of the modules that could be automated by the current technology on hand. [1] Scientists’ opinions on this issue are different. While some scientists say that automation will gradually replace human workforce greatly, some others declare that it is impossible to substitute human workforce completely and that digital systems would be used to facilitate human force, thus digital systems would only be used for assisting human workforce. [2, 3, 4]

In the context of employment and recruitment across industries and geographies skills would become critical both for companies’ and universities’ success. As reports about graduates’ employment are among key indicators for the universities and employers compete with each other to recruit and retain valuable employees. Moreover, globalization together with the digital transformations leads to blurring of lines between countries, economies, institutions and employees are able to build ‘boundless’ careers.

Concluding the idea, one can say that in order to perform effectively within Industry 4.0 environment, employees should get into the habit of continuous learning not only in their profession, but also in a wider cross-disciplinary and cross-cultural perspective.

2. Educational product
Industrial sphere as a leading one usually has a deep impact on all spheres of our life, especially, on the spheres closely connected with it such as education, because it services the sphere on one hand, and on the other hand, educational institutions might act as an independent subdivision that could be
compared with an industrial one producing personnel. This comparison is appropriate when we mean technological universities and colleges.

Figure 1 presents a training process for the graduates with technical majors; we have adapted the figure from the research, conducted by Wuest T. [5].

| INPUT                              | OUTPUT                                      |
|------------------------------------|---------------------------------------------|
| **Raw material:**                 | **PRODUCT (STUDENT) DEVELOPMENT**           |
| students’ knowledge and skills     | Industry 4.0 EXPERTS                       |
| **Level of education:**            | technical and engineering employees         |
| - Bachelour                        | of first stage                              |
| - Master                           | technical and engineering employees         |
| - Post-graduate                    | of second stage                             |
| **Workload:**                      | technical and engineering employees         |
| Contact hours                      | of third (highest) stage                    |
| Independent hours                  |                                             |
| Teaching/ training technology      |                                             |

**Figure 1.** Process of developing an educational product (4.0 Experts).

We suggest that we could treat entrance students to a technological university as some raw material to manufacture a product. Depending on the educational level, chosen by a student, technical and engineering employees of different ranks could be trained.

The teachers and educators’ workload together with students’ efforts could be compared with the manufacturing process. Filos [6] considers manufacturing products to be a process overlapping all the input components, for example, raw materials, equipment and manufacturing operations. In addition, he focuses on the participants of the process and the operations divided among them. The educational process demonstrates the same: we could highlight planning and future design of products (experts) and their further quality monitoring and control.

However, the educational sphere is an independent one; we speak about its distinguishing characteristic meaning training students is not a type of production as we do not manufacture a specialist from scratch. But depending on the stage of training level we convert and transform a student into an expert 4.0, and they also pass through several development stages as figure 1 shows.

Therefore, when we compare an educational process to a manufacturing one, it is necessary to realize that raw material in our occasion is a product A formed by the previous educational institutions. The technical university adds more workload to transform it into a finished good (product A”).

**Figure 2.** Product development.
Higher education training provides product transformation rather than their complete development from raw material. A higher education product could be described as an output based on both participants of the process: a student and an educator to meet the requirements of the third participant, an industry. The industry is a customer of a technical university whereas graduates are its products.

As the research [5] underlines, products need to have characteristics to be easily noticed and measured, such as: length, depth or weight, but some characteristics are almost impossible to treat in physical way, like in our research concerning specific products Industry 4.0 Experts. The quality of a trainee, for example, ability to work in a team, or communication skills, find and process information are hindered to check. We also suppose that the graduates’ characteristics required by the Industry 4.0, like interdisciplinary skills, research skills are hard to measure though they are important for Experts 4.0. Therefore, here we need to speculate about special quality control procedures and technology to improve the future employees.

First, the industry formulates their requirements as a technical task to a university; judging by the brochure [7], we could outline four main trends in the demands to the experts 4.0: they have to provide higher productivity, higher intelligence, to be able to participate in more transparent and controllable production process. For this, technical universities can adequately measure only one skill – their graduates’ technical knowledge through their tests and examinations. However, practical work will demonstrate high intelligence and other skills.

University graduates as products should be exposed to several stages of quality control at an enterprise. That is an industrial enterprise as a university customer can check if the product meets their requirements at the final stage of the control. However, as Wuest T. mentions [5], such quality control cannot be completely unbiased since the requirements could be vague and hard to control. Moreover, the control procedure should take into account the quality of “the raw material” and possibilities of the university to provide flexible technology to be applied to the product transformation. We demonstrate the components of the quality control system at figure 3.

![Figure 3. Product quality components.](image)

3. Changing role of university education in Industry 4.0 era

Reviewing the stated above, we could assume the Universities play a vital role in performing the needs for education of industry 4.0 experts. Choosing technologies in training of industry 4.0 experts is connected with elimination of lower skilled jobs through automation and digitalization. This transformation requires a significant change in the future workforce skill formation at the Universities.

There are five parameters important for the required qualification of skilled workers in industry 4.0:

- comprehensive integration and information transparency
- increasing automation of production systems
- self-management and decision-making by objects
- digital communication and interactive management functions
- flexible use of the staff.

Hence both IT and production knowledge will be important in the new period of inter-functional roles. That is why educational system should shift its object focus on broader skill sets and job-
specific capabilities and offer new formats of life learning (continuing) education. The thing is that not only the educational content should be changed but also methods of skill development have to be at the cutting edge of the moment to meet the requirements of a new generation of employees. Peter Fisk defines a new vision for the future of education as “Education 4.0” in a wider scope as:

- responding to the needs of industry 4.0, where man and machine align to enable new possibilities
- harnessing the potential of digital technologies, personalized data, open sourced content, and the new humanity of this globally connected, technology-fueled world
- establishing a blueprint for the future of learning—lifelong learning—from childhood schooling to continuous learning in the workplace.

Peter Fisk characterizes future education as personalized, repackaging, peer-to-peer and continuous based on the Clay Christensen’s ideas. According to Fisk, the learning process will change the old mindsets in the near future whether it is classroom or workplace, online or offline, structured or unstructured, taught or learned, standardized or not, certificated or not. [9]

Engineering programs also need to be changed. Engineering education requires the collaboration of academic disciplines with the development of highly complex, socio-technical systems. Future engineers need the skills to adapt the innovation cycles rapidly, and IT is the primary driver of innovation in future industrial context. In this regard, universities should focus on building specific capabilities for the new roles and adapting their curricula to meet companies’ expectations for Industry 4.0 skills. They also need to encourage soft skills that enable workers to be open to ongoing capability development, interdisciplinary collaboration, and innovation.

In connection with big data, dealing the following subjects should be included in the universities’ curricula: cloud computing, data analytics, artificial intelligence, machine learning, virtualization etc. The main issue here is structuring of university programs so that the innovation and entrepreneurship management skills of the engineers would be developed. Additionally, e-learning technologies such as gamification, virtual labs, and learning analytics should support the engineering education process.

Therefore, to fulfill the requirements of Industry 4.0, the technical universities have to organize a specific educational process in accordance with the customers’ demands. We could also assume that some jobs at Industry 4.0 need experts trained at individual courses or with special technology. We feel that Kinash’s proposal “to use personalization at the university level” [8] is stick to the point, especially for some disciplines. Those personalized technology contribute better to Industry 4.0 job requirements and, consequently, correspond to high quality though, in this occasion, a graduate can have so called ad-hock training.

Nevertheless, some researchers underline the advantage of such training programs as they develop versatility to the trainees and transparency to the teaching process that can result in better management of quality control. [10] They unite the personalized technology with computer assisted learning and highlight the graduates’ effectiveness, as both technology support trainees’ independence in choosing learning trajectory for the specific job. In addition, high quality of teaching material and teaching process transparency, and unavoidable necessity for students to further develop their intelligence through meta-cognition.

Personalization of the education process at least when students are taking their final years at university could contribute to the trainees’ professional development reaching this via technology-enhanced learning. [11] The idea is not new since in 2005 researcher Laurillard mentioned that online tutors and resources are flexible to meet both Industry 4.0 and trainees’ requirements, as they are easy to adapt to their needs, although a mixture of face-to-face and online learning is also possible. [12] Such traits of blended learning are even more important at Master level and post-graduate level when practical experience at an industrial enterprise takes the majority of trainees’ time, and learners’ aims and needs are adhered.
Kim and coauthors [13] specify personal engagement into the educational process and their personal responsibility for the result of training, therefore, their motivation is considered to be high due to the technology-enhanced learning.

4. Conclusion

Summarizing our research, we focus on the main characteristic of the industry of the future and its requirements to the personnel: technologically aware, digitally approached though versatile and flexible.

Training industry 4.0 experts the technical universities is likely to adapt a few industrial traits such as developing their educational process similar to manufacturing one and a quality control system for the products – experts 4.0. However, based on their flexibility and independence, the universities need to develop their own standards considering the complexity of every trained person, proposing the various training technology to them and adapting the teaching process as computer aided and personalized.

We could also state that the new Industry 4.0 era teaching covers numerous disciplines and uses an increasing number of methods that highlight the complexity. There is a great connection between the new education requirements of industry 4.0. Designing integrated engineering programs that span these new engineering education challenges may minimize the gap between the universities and the industrial environment.

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