The 12th International Conference Interdisciplinarity in Engineering

State-of-the-art Analysis on the Knowledge and Skills Gaps on the Topic of Industry 4.0 and the Requirements for Work-based Learning

Liviu Moldovan[a]*

[a]University of Medicine, Pharmacy Sciences and Technology of Targu Mures, 38 Gheorghe Marinescu street, Tîrgu Mureş 540139, Romania

Abstract

This paper reports the state-of-the-art analysis on the knowledge and skills gaps on the topic of Industry 4.0 and the requirements for work-based learning (WBL) consists of the results from a large-scale survey conducted among two target groups: manufacturing SMEs and VET providers/trainers/consultants from 6 European countries and cross-sectional analysis of the viewpoints of manufacturing SMEs representatives vs. VET providers. It is part of the Erasmus+ project "Work-based training approach in the field of Industry 4.0 for competitive European Industry"- iNduce 4.0. Based on the results from the researches carried out in all partners' countries are defined the key points concerning the elaboration of the iNduce 4.0 training course and the iNduce 4.0 Practical methodology for WBL. It foresees the awareness of the Industry 4.0 topic, the training modules developed, the needed skills and the proportion of theory and practice.

*Keywords:*Industry 4.0 skills; work-based learning; factory of the future; manufacturing

1. Introduction

With the advent of new technologies, European Union (EU) manufacturing Small Medium Enterprise (SMEs) are already facing the 4th industrial revolution or Industry 4.0, where computers and automation come together in an

---

entirely new way, with robotics connected remotely to computer systems equipped with machine learning algorithms that can learn and control the robotics, leading to drastic structural changes in operations executed by human operators. Industry is a central pillar of the European economy–the EU manufacturing sector accounts for 2 million companies and 33 million jobs. The challenge is to ensure that all industrial sectors make the best use of new technologies and manage their transition towards higher value digitised products and processes, commonly known as "Industry 4.0" [1].

The digital transition alters requirements for employees across all steps of the value chain– from development on through production to sales and brings the need of completely new skills in employees. According to the New Skills Agenda for Europe "Work in industry at all levels from operators to engineers and administrative staff will increasingly consist of designing, maintaining and supervising intelligent machines that assist in the performance of tasks. This will require different skill sets. Future jobs will require an appropriate mix of basic, soft and technical skills, notably the digital and business-specific skills that education and training systems are not yet fully addressing. Industry has an active role to play in the definition and training of the key skill sets and competences" [2].

Taking into account the aforementioned, with the 4th industrial revolution already taking place, manufacturing SMEs are facing the need of re-shaping production processes, which on the other hand requires new skills and knowledge of the employees in the "factory of future". To do that, SMEs need to be equipped with adequate training tools providing the technical knowledge on the topic of Industry 4.0 as well as innovative training approaches that will enable them to nurture the necessary skills in their current and future employees.

Despite the increasing attention paid to changes in jobs and skills generated by Industry 4.0, research in this domain is still scarce [3]. According to PwC Global survey, 2016 regarding Industry 4.0 among SMEs, respondents report their biggest implementation challenge isn't choosing the right technology; it's the lack of digital culture and skills in their organisation [4]. Cyber-phisical systems [5] in lean environments [6], practice oriented learning [7], project based learning [8] enable the creation of work environments with new opportunities to purposefully facilitate learning. Also innovative tools [9, 10] and models [11] for vocational education and training and evaluation models [12] by means of mobile technology [13] may provide a learning experience that facilitates the development of Industry 4.0 skills and competences.

Taking into account that Industry 4.0 solutions would vary depending on the type of manufacturing, in order to acquire the necessary skills, employees have to be trained in the work place–work-based learning (WBL). Yet, "SMEs face particular challenges in engaging with WBL, given their smaller workforces, limited resources and lack of familiarity with the WBL regulatory and administrative framework." [14]

The "Work-based training approach in the field of Industry 4.0 for competitive European Industry"- iNduce 4.0 - project no: 2017-1-RO01-KA202-037222 is an Erasmus+ project, promoted by a consortium of organizations from 6 EU countries: Romania, Poland, Portugal, Germany, Bulgaria and Cyprus which aimed at promoting work-based learning on the topic of Industry 4.0, with special attention to apprenticeship training, by involving social partners, companies and Vocational Education and Training (VET) providers [15].

The specific objectives of the project are:
• creating flexible learning package for work-based learning aimed at providing fundamental technical knowledge on the topic of Industry 4.0;
    • creating thorough methodology for WBL current and future (VET students/apprentices) SME employees on the topic of Industry 4.0 and thus boosting SMEs' capacity for transition by nurturing the necessary skills for the "factory of the future".

2. Purpose and method

This paper reports the results of the research performed in the consortium in order to set the basis for elaboration of the iNduce 4.0 training course and the iNduce 4.0 Practical methodology for WBL in accordance with the target groups' needs as well as to provide basis for forming recommendations for evidence-based policy in the field of WBL. The suggested training modules by consortium are 1- Introduction to Industry 4.0; 2- Solutions for Smart Production Environments in the manufacturing sector; 3- Smart Robotics; 4- Application of CPS/IoT across the process chain.

It describes and analyses the findings of the target group survey in the field of WBL, conducted in the 6 European countries. The State-of-the-art analysis on the knowledge & skills gaps on the topic of Industry 4.0 report consists of the following:

- Results from a large-scale survey conducted among two target groups - manufacturing SMEs and VET providers/trainers/consultants from 6 countries;
- Cross-sectional analysis of the viewpoints of manufacturing SMEs representatives vs. VET providers.

3. Target group survey

The target group survey was conducted among two target groups - manufacturing SMEs and VET providers/trainers/consultants from 6 countries in the period November 2017 – January 2018. It is focused in 2 main directions: defining the knowledge and skills gaps in the field of Industry 4.0 and defining the main hardships in organizing work-based trainings according to manufacturing SMEs and VET providers.

Each partner performed the surveys via chosen communication means – via email, phone, electronic software (e.g Google docs, SurveyMonkey, LimeSurvey, etc) or face-to-face meetings. The targeted types of respondents from SMEs were: managers of manufacturing SMEs; heads of departments (production, logistics, etc.) in manufacturing SMEs; employees from human resource departments, other relevant staff and for VETs they were trainers, consultants, training developers; mentors; other relevant staff of VET organisations. The total numbers of respondents reached are 117 SMEs and 77 VET providers (Fig. 1).
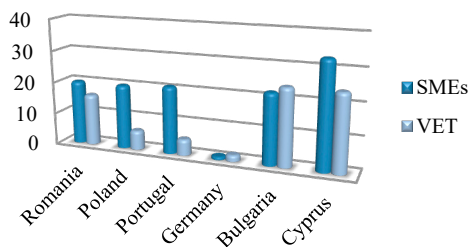

Fig. 1. Respondents from each country.

As it is visible from figure 1 the representatives from SMEs were more responsive to the survey than the VETs except for Bulgaria where VETs responses are more. This might be due to the fact that SMEs are more interested by the project topic. Responses received in Germany are less compared to other countries however they come from big umbrella organisations representing two enterprises (VET and social service institutions) operating in more than 1.150 locations all over Germany with numerous VET centres and employing 23.500 people.

4. Cross-sectional analysis of the viewpoints of manufacturing SMEs representatives vs. VET providers

4.1. Identification of respondents

- *VET providers*

As it is visible on figure 2 the majority of the respondents from VET providing organisations are managers (37,66%) , followed by expert/consultant/advisor (24,67%), and trainers and mentor (23,37%).

According to figure 3 the vast majority of the VET respondent provide training at the workplace (41,56%), followed by VET providing training at adult education centers (38,96%) or continuous non-formal education (35,06%). These results indicate that the majority of VET respondents deal with WBL and therefore their feedback could be very useful.

- *SMEs*

The vast majority of respondents from SMEs are managers, office-workers and department managers (Fig. 4). Respondents were representatives from different industries mainly Machinery; Metalworking; Electronics; Electrical

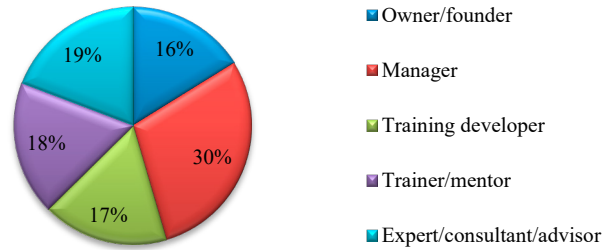engineering, which are all industries on which Industry 4.0 will have significant impact.
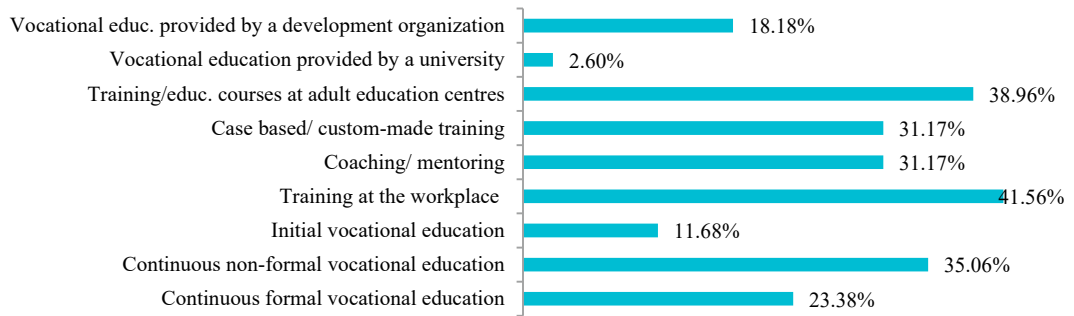

Fig. 2. VET respondents.

Fig. 3. Type of vocational education provided by the respondents' organization.
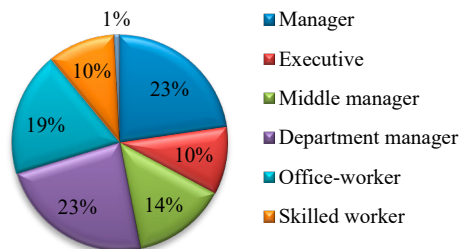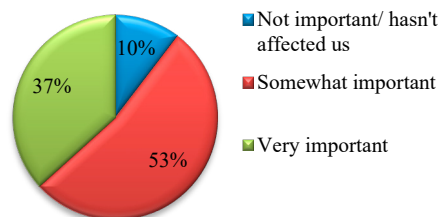

Fig. 4. SMEs respondents.

Fig. 5. Importance of Industry 4.0 SMEs.

   More than half of SMEs surveyed in partner countries realize the importance of changes arising from Industry 4.0 as they have pointed it is somewhat important. More than 1/3 says it's very important to their operations and only 10% (11 out of 117 SMEs) deem it unimportant. These results indicate interest towards the topic and awareness on the fact that it is important to be in line with the changes arising from Industry 4.0 (Fig. 5).

4.2. Industry 4.0 skills and knowledge gaps

For most of the participants in the survey from both representative groups, the concept of Industry 4.0 is well known, as in Bulgaria alone the majority of respondents from SMEs and VET declare that they are not familiar with the concept and in Germany neither consider their staff to be familiar with the concept of Industry 4.0 (VETs/SMEs) nor see themselves acquainted with it (SMEs).

Also it is noteworthy that representatives of *SMEs are more familiar with the idea of Industry 4.0 in comparison with the VET* providers which may be due to the fact that they are directly affected. This indicates that partners should disseminate the project objectives and results more to VET providing organisations in order to raise their awareness on the topic and its importance.

From the results of the research of all partners, it is clear that the majority of respondents consider staff in their enterprise isn't familiar with the concept of Industry 4.0. Meanwhile for the majority of SMEs representatives Industry 4.0 and changes arising from it are important to them.

Taking into account the above mentioned and the fact that most of the participants are in managerial positions and fewer are employees or administrative personnel it indicates that since the trend is still new so far Industry 4.0 has affected only partially the organizations, mainly the management sector. Furthermore we can presume that available knowledge of the industry is due to self-interest and self-awareness rather than corporate organization and management who are acquainted with the concept of the Industry understand its importance but doesn't take action to introduce it to its employees which presumably could be due to lack of resources or of access to proper education.

Following the logic of the above-presented results, which show a low level of awareness of the subject at company level, it is not surprising that all suggested modules prove to be of high interest for both target groups which indicates that a *comprehensive package of training materials will be highly appreciated*. Though, as visible on figure 6, Module 1 "Introduction to Industry 4.0" and Module 2 "Solutions for smart production environments in the manufacturing sector" are seen to be the most necessary ones.
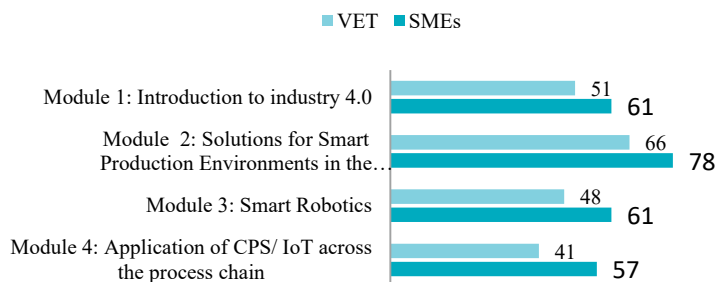

Fig. 6. Industry 4.0 training topics.

The interest in the subject of Industry 4.0 is additionally proven by some relevant suggestions for additional topics to be addressed by the iNduce 4.0 training course which might be integrated as part of the listed modules or to be developed as additional modules.

Suggested modules from VETs are: Digitization of the training and training of the personnel in the industry; Organization of processes in digital environment; Security and protection of cyber-physical systems, including legal base; Encoding language.

Suggested modules from SMEs are: Applied cooperation between clusters and scientific thought; Competitiveness, Trade and Development of SMEs.

With regard to the necessary skills for successful implementation of Industry 4.0 it is difficult to identify common to all participating countries ones, most likely because the skills required depend to a large extent on the industry in which a company operates. However, we may point out some skills that stand out among the responses of SMEs representatives like *Technical skills, Complex problem solving, Cognitive analytics and System skills*.

On the other hand, VET providers mainly have chosen *Complex Problem Solving Skills and Technical skills,* which prove to be the crossing point between the two target groups. Some of the other more chosen answers are *Content skills, Systems skills and Resource management.*

It is interesting that SMEs and VET providers have different view on the importance of skills. Only in Cyprus for example respondents point out System Skills' with percentage of 51.52% for SMEs and 70.83% for VETs, but in the meantime both groups claim that everyone lack this skill. *This data confirms the need for this study in order to align the needs of companies and training offered.*

As regard to the skills people lack most of them coincide with those listed as the most important. What makes impression is that in both questions the answers are quite varied and the choice of participants is numerous which indicates that *only one or two skills are not enough when it comes to Industry 4.0 but a set of skills is needed.* Partnership should take this into account when developing the Induce 4.0 project training materials and try to target as many skills as possible.

In order to acquire the missing skills, the participants in the study had to indicate their preferred way of learning. As the question was open-ended, the respondents gave a variety of answers, some focusing on the course theme, others on methods of teaching and learning.

However, it can be concluded that SMEs representatives prefer *practical training connected with the workplace and the profession, on the job training based on real-time examples and case-studies on the workplace including in-house training, onsite learning online courses, work-based learning.*

Regarding VET providers, they unite around idea of practical training and onsite training.

Referring to the results one may conclude, that *practice-focused training is preferred with the option to be tailored to a different ways of teaching such as on the workplace training, blended learning, online courses.*

5. Experience with work-based learning

In almost all countries (except for Poland and Germany) participating in the survey SMEs are more experienced in WBL initiatives than VETs and only in half of countries the experienced respondents are more than the unexperienced ones (Fig. 7). The most common kind of experience in both target groups are internships followed by apprenticeships for SMEs and training and consulting services for VET providers.
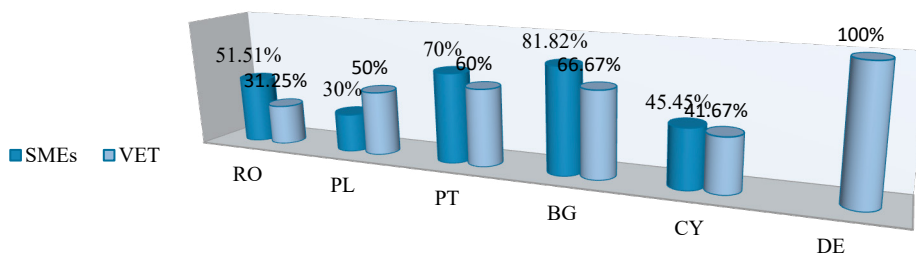

Fig. 7. Experience with WBL initiatives.

In fact, it is noticeable that in each country the rates between SMEs and VET providers with experience with WBL activities are almost the same which indicates that there might be a correlation between activities of VET and SMEs. The same is valid for VET providers offering on the workplace/onsite training programmes to business and SMEs having onsite training programmes implemented within their organization (Fig. 8). For example in Bulgaria *"10 out of 24 VET providers have stated that they offer on the workplace /onsite training programmes to business and 10 out of 22 SMEs have confirmed they have onsite training programmes implemented within their organization".*

Only few of the participating VET organisations that provide onsite training programmes to companies offer any training related to Industry 4.0. One reason for this might be the fact that the topic is still new and VETs haven't

managed to develop courses already and they themselves are not familiar enough with the matter. Other reasons for the lack of offering stated by VETs are lack of information resources, low demand / interest in educational service, reluctance of employers and employees.
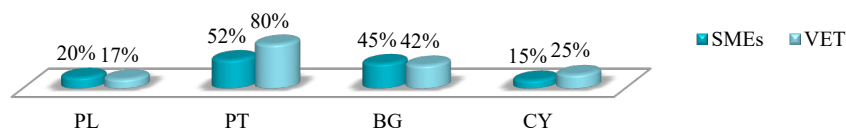

Fig. 8. Ongoing onsite trainings.

In comparison, SMEs stated out as obstacles in applying WBL programmes for new employees/ students lack of time and resources, lack of theoretical materials to combine with practical elements, legal regulations.

The level of awareness on the topic combined with the lack of information resources and theoretical and practical materials pointed by SMEs and VETs as obstacle towards organizing WBL confirms the importance of the project and the need of such training materials and courses as intended to be developed.

6. Preferences and training needs

As visible from figure 9 SMEs and VET providers have similar preferences according to the technological solutions/functions in an interactive educational website. *The most valuable ones for both target groups are: interactive evaluation tests, possibility to download files and exchange messages with trainers and colleague trainees, discussion forum.* For SMEs the PDF content is also somewhat important as well as library accessible until 12 months after concluding the training course. VETs will also value to have PowerPoint content, chat and library.
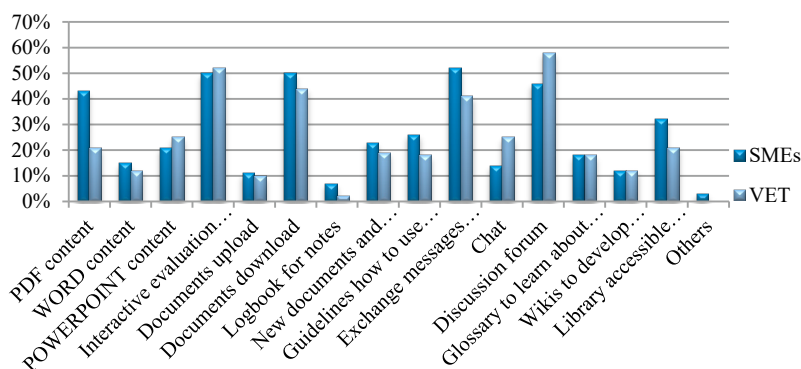

Fig. 9. Most important features of interactive website.

Therefore, these functionalities should be taken into account when planning the educational portal where the iNduce 4.0 training course will be available to users.

As regards the best proportion of theory and practical on the job training when organizing WBL in the field of Industry 4.0 results prove that *both SMEs and VET providers consider that practice should be more than theory* with the majority of answers stating 30/70 theory against practice. Still there are also a significant number of responses that state equal proportions are preferred. In order to satisfy the needs and expectations of target groups iNduce 4.0 deliverables should be both practical and theoretically orientated in order to allow trainees to choose the best option for them and thus be usable by more people.

7. Conclusion

Based on the results from the researches carried out in all partners' countries, the following key points concerning the elaboration of the iNduce 4.0 training course and practical methodology for WBL could be defined:

- The topic of Industry 4.0 is considered important but there is a low level of awareness of the subject at company level. What are more SMEs are better acquainted with the industry concept than VET providers' representatives.
- A comprehensive package of training materials will be highly appreciated with focus put on Module 1 "Introduction to Industry 4.0" and Module 2 "Solutions for smart production environments in the manufacturing sector". During development of the course it should be taken into account the additional modules suggested by participants in the survey.
- Only one or two skills are not enough when it comes to Industry 4.0 but a set of skills is needed. iNduce 4.0 Methodology should address as many skills as possible with focus on Complex Problem Solving Skills, Technical skills and Systems skills.
- iNduce 4.0 training course should be more practice-focused with the option to be tailored to a different ways of teaching such as on the workplace training, blended learning, online courses.
- Both SMEs and VET providers consider that practice should be more than theory (70%/30%). Although in order to be usable by more people the needs and satisfy expectations of all representatives of the target groups iNduce 4.0 deliverables should be both practical and theoretically orientated in order to allow trainees to choose the best option for them and thus be usable by more people.

The educational portal on which the iNduce 4.0 course and methodology will be available should have interactive evaluation tests, option to download files and exchange messages with trainers, discussion forum.

Acknowledgements

References

[1] G. Oettinger. Europe's future is digital. 2015, Speech at Hannover Messe, available at: https://ec.europa.eu/commission/commissioners/2014-2019/oettinger/announcements/speech-hannover-messe-europes-future-digital_en

[2] A new skills agenda for Europe. Communication from the commission to the European parliament, the council, the European economic and social committee and the committee of the regions. COM(2016) 381 final. Brussels, 10.6.2016, available at: https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-381-EN-F1-1.PDF

[3] M. Pinzone, et al., Jobs and Skills in Industry 4.0: An Exploratory Research. In: Advances in Production Management Systems. The Path to Intelligent, Collaborative and Sustainable Manufacturing, Lödding H., et al. (eds). APMS 2017. IFIP Advances in Information and Communication Technology, 513. Springer, Cham.

[4]PWC. 2016 Global Industry 4.0 Survey, available at: https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf

[5] G. Schuh, T. Gartzen, T. Rodenhauser, A. Marks, Promoting Work-based learning through Industry 4.0. Procedia CIRP, 32 (2015), 82-87.

[6] F. Moldovan, New approaches and trends in health care, Procedia Manufacturing 22 (2018), 947-951.

[7] H. Karre, et al., Transition towards an Industry 4.0 State of the art LeanLab at Graz University of Technology. Procedia Manufacturing, 9 (2017), 2016-213.

[8] C. Villa, et al., Project-based collaborative engineering learning to develop Industry 4.0 skills within a PLM framework. Procedia Manufacturing, 13 (2017), 1269-1276.

[9] L. Moldovan, Design and development of innovative tools and models for e-learning in central and western Romania, Quality Management in Higher Education, 2 (2010), 543-546.

[10] L. Moldovan, Innovative tools and models for vocational education and training, Review of Manag. and Economic Eng., (2010), 282-290.

[11] L. Moldovan, Innovative models for vocational education and training in Romania, Procedia SBS, 46 (2012), 5425-5429.

[12] L. Moldovan, Training outcome evaluation model, Procedia Technology, 22 (2016), 1184-1190.

[13] L. Moldovan, New evaluation model by means of mobile technology, Procedia Technology, 19 (2015), 1094-1101.

[14] European Commission. Work-Based Learning in Europe. Practices and Policy Pointers, available at: http://ec.europa.eu/dgs/education_culture/repository/education/policy/vocational-policy/doc/alliance/work-based-learning-in-europe_en.pdf

[15] iNduce 4.0 project website: http://induce-project.eu/ro