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# Transportation Systems

## Managing Performance through Advanced Maintenance Engineering

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# Chapter 10
# Vocational Education and Training in Transportation Maintenance 4.0: A Note

**Alberto Martinetti**

**Abstract** Vocational Education and Training (VET) represents a key factor for the development of countries and society. Due to radical changes and new challenges in technology and in societal needs, VET has to re-think its position in the education field as well for better fitting within the new job requirements. The chapter will focus on the relations between VET and Maintenance 4.0 environments analysing opportunities with particular attention to works in transportation systems. First, the work will discuss the actual context in comparison with the past decades focusing on the European situation. Second, the main points of VET and Transportation Maintenance 4.0 will be pinpointed. After that, a reflection on how those concepts can be combined in transportation systems will be offered. Finally, discussion and conclusion will reflect on how to move forwards for taking advantages of VET on a long-term horizon.

**Keywords** Vocational education and training (VET) · Maintenance 4.0 · Transportation

## 10.1 Introduction and Context

The volatile job market that has characterised the last two decades and the unstable economic situation generated by the recent crisis have affected the employment rates in several countries of Europe (Fig. 10.1). The unemployment is a cross-borders phenomenon, sometimes even not prevented by social position. It affects experienced workers and young people in every job sectors (Eichhorst et al. 2015).

As also highlighted by several sources, this problem has been (and still is) more problematic in European countries where people encountered difficulties to enter in the job market even before the financial crisis. In those countries, where the Vocational Education and Training (VET) is less strong and used, people tend to have less consolidated practical skills. As a consequence, they are often considered by possible employers not as an investment but as a cost during the first 6–12 months

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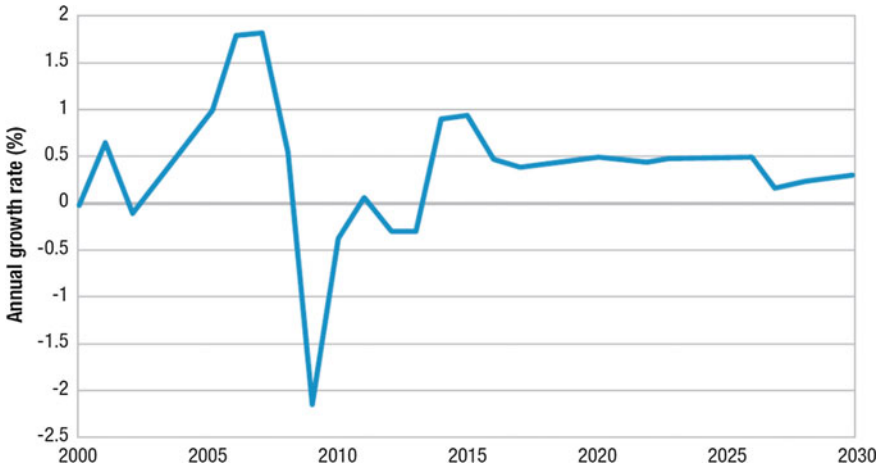


**Fig. 10.1** Employment annual growth rate, EU-28+3 (Cedefop and Eurofound 2018b)

of employment. This leads to a general trend that generates resistance in hiring new employees. In financial crisis times and job scarcity, when resources and processes need to be efficient from time zero, the latter is greatly amplified.

The changing nature of work due to the introduction of new technologies and automation could route the described mechanism towards very different scenarios:

- A working environment where human resources is enhanced and integrated into a global value chains, where new technologies create new job positions;
- The reduction of production equipment cost puts at risk those workers in low-skill jobs engaged in routine tasks. These are the occupations most susceptible to automation (World Bank 2019).

The mentioned introduction of new technologies can certainly be referred to the big changes brought by Industry 4.0 (I4.0). In general terms, I4.0 is a way to define industry and production processes empowered by the introduction of IT solutions, robotics, condition-monitoring devices, and their interconnection (Kagermann et al. 2013; Deloitte 2015; Sniderman et al. 2016; Reyes Garcia et al. 2019). These Cyber-Physical Systems (CPS), considered as main driven changes in the I4.0, requires specific training and competences in order to be a value for the system which they are deployed in. It opens the opportunity for the VET to re-take a central role as a connector between industries and workforce. In this scenario, maintenance is one of the application areas, and it can be referred to as Maintenance 4.0 (Kans et al 2016).

The following sections will reflect on opportunities that can arise connecting VET and Maintenance 4.0 jobs within the transportation sector.

## 10.2 Vocational Education and Training (VET) and Transportation Maintenance 4.0

Vocational education and training are manifold; it is the most heterogeneous of the main education and training sectors in Europe today. VET overlaps with other parts of the education and training system in many cases (Cedefop 2017a, b). As pinpointed by several authors (Biemans et al. 2004; Detmar and De Vries 2009; Finch et al. 2007; Toolsema and Nijhof 2003; Akkerman and Bakker 2012), a major concern has always been the different approaches between school and works for most of the VETs. For example, in most of the Southern European Countries, VET are mostly related to upper-secondary education, training at school and not within a firm; VET in firms usually is in place only for fixed-term contracts (Eichhorst et al. 2015). However, several European countries after the acknowledgement reached in Riga in 2015 are stressing the value of "responsive VET" to contribute to the international competitiveness of the labour force in a global context (Cedefop 2018a).

Moreover, VET can really play an important role in reducing high school drops out giving an attractive alternative to the ones that are interesting in learning a job.

### *10.2.1 Vocational Education and Training (VET)*

According to the terminology settled by Cedefop (2014), VET comprises all the actions necessary to equip people with knowledge, know-how, skills and/or competences required in particular occupations or more broadly on the labour market. Figure 10.1 highlights general skills that a VET should provide.

VET offers several options from certifications and diploma programs to associate degree programs. High school programs can provide a wide range of courses and work experience programs, designed to introduce students to different trades. Community colleges, technical schools, and career colleges provide several VET programmes as well, to have more tailored studies matching with different student background; these courses give utmost importance to hands-on training in order to transfer immediately applicable competences (McCoshan et al. 2008).

As it is possible to note in Fig. 10.2, VET needs to transfer a set of different skills. The importance and the balance of the skills are greatly influenced by the programme of the VET and by the typology of job considered. However, due to the globalisation of the market, fostered by increasing mobility of both job positions and workers, a VET cannot be considered complete if the trainee/student does not receive basics of cultural awareness, social science, team working and management. Nowadays, several jobs require multiple operators at the same time and at the same location. Maintenance of transportation systems is among those indeed. In this scenario, workers need to be prepared for smoothly operating together both from technical perspective and from group synergy perspective.


**Fig. 10.2** Basic skills to acquire during a VET

This point implies that a VET programme mono-oriented to technical skills transfer will create deficit knowledge in the field of team working. A similar consideration can be done likewise for a lack of technical knowledge.

Even if Education and Training in VET programmes are often considered (correctly) together having similar scopes, it is valuable to underline that they are slightly different in some of the aspects.

If we refer to the Bloom's Taxonomy (1956) the concept of *Vocational Education* is focused on absorbing and remembering educational contents and understanding information (mostly audio and visual learning). On the contrary, the *Vocational Training* is oriented in letting the student apply concepts and operate in a real scenario and analyse situations. Procedures are emphasised through repetition and typically hands-on application with constant instructor evaluation for checking the accuracy. Figure 10.3 offers a visualisation of the aims of Vocational Education and Vocational Training. It is important to remark that these definitions are not rigid. Their boundaries could vary due to several causes: different learning goals of VET, different industrial sectors, differences in Country educational programmes, etc.

According to the definitions discussed, it is valuable to add that the top of the Bloom's Taxonomy pyramid, generally called "Create", meant for producing new

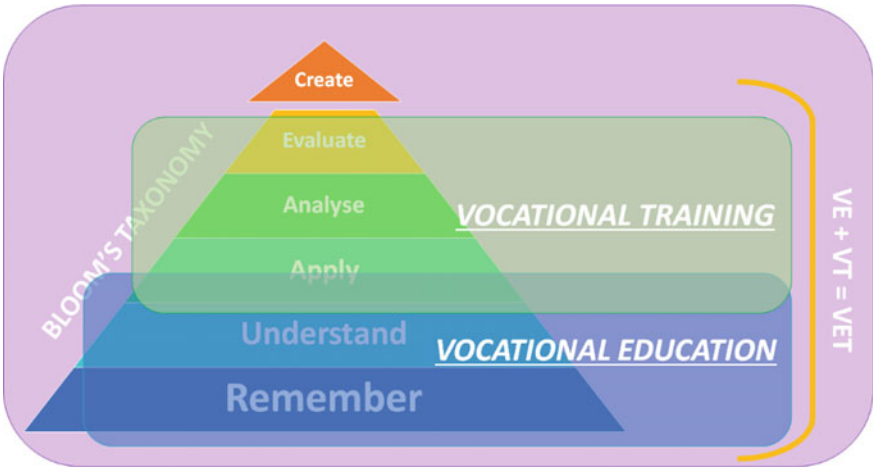


**Fig. 10.3** Vocational education and vocational training in relation to Bloom's taxonomy

original works, rarely is included in VET programmes. The reason for that lies in the overall aim of VETs: providing proper knowledge and skills for understanding and applying competences.

### *10.2.2 Transportation Maintenance 4.0*

In the same way of most occupational sectors, transportation has been heavily affected by the changes brought by I4.0. The introduction of CPS did not only change the level of interconnectivity between systems, machines and equipment, but change drastically also the work organisations, the work operations and the opportunity for maintenance applications (Reyes Garcia et al. 2019). It influenced even the way of designing assets in order to perfectly combining mechanical, electronic and IT components. It promoted the development of a Maintenance 4.0 concept.

An interesting example is shown in Fig. 10.4. It explains how working hours and hourly relative working place distribution of three train series (Stadsgewestelijk Materieel-SGM, Sprinter Light Train-SLT, and Sprinter New Generation-SNG) operated by the Netherlands Railways (NS) changed with the introduction of I4.0 related sub-systems.

Besides the overall reduction of working hours per single coach through the decades, if for maintaining a SGM train (in service since 1975) 80% of the time was spent under the train in the pit, the introduction of SNG in 2018 has deeply changed the working procedures and the workshop layout. The maintenance personnel are now required to spend 56% more time on elevated platforms for working on IT and electronic systems placed on the roof of the train (Table 10.1) than for

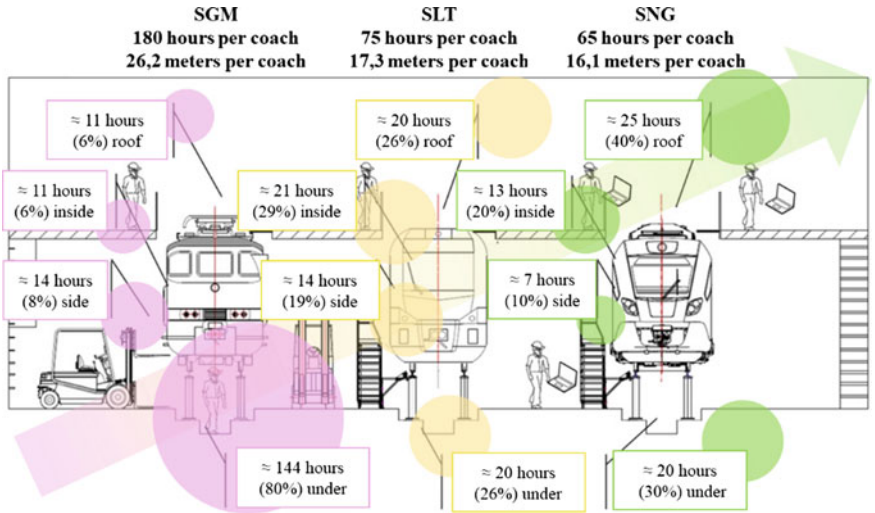


**Fig. 10.4** Evolution of maintenance time distribution for the SGM, SLT, and SNG train series operated by NS

**Table 10.1** Maintenance working hours for different train series divided per train location

| Working hours / Train location | SGM (h) | SLT (h) (±Δ% of SGM) | SNG (h) (±Δ% of SGM) |
|---|---|---|---|
| Roof | 11 | 20 (+ ≈ 45%) | 25 (+ ≈ 56%) |
| Inside | 11 | 21 (+ ≈ 48%) | 13 (+ ≈ 16%) |
| Side | 14 | 14 (± 0%) | 7 (− ≈ 50%) |
| Under | 144 | 20 (− ≈ 87%) | 20 (− ≈ 87%) |
| Total working hours | 180 | 75 (− ≈ 59%) | 65 (− ≈ 63%) |

the SGM. This change in the nature of work has forced NS to revise their working procedures and to build workshop suitable for the new working time distribution.

It brought several challenges not only in terms of working re-organisation, safety procedures, risk management but also in terms of competences and knowledge that the personnel needs to have for reliably working on the new assets.

Maintenance 4.0 does not only affect railway industries. It has already several applications in different transportation sectors: interconnection traffic management systems, real-time health condition-monitoring systems for infrastructures (tunnels, bridges, waterways, roads' pavements, etc.).

As also discussed by Kans et al (2016), Maintenance 4.0 can play a significant role in transportation systems supporting the goals highlighted by European Union such as long-term strategy for society development, encouragement of efficient and

"smart" solutions for improving reliability, re-organisation of work processes and work methodology in order to increase the overall safety.

## 10.3 VET at the Time of Transportation Maintenance 4.0

As defined in the Sect. 10.2.2, VET provides competences and skills for a specific trade, craft or job function (Roy 2018).

Even if in the past this training was confined to certain trades like welding, automotive services and carpentry now the horizon of VET has expanded with the evolution of time and a multitude of options is available to acquire extremely specialised skills.

Since Maintenance disciplines, as said, are changing due to new technologies introduction, VETs focused on Maintenance need also to change for training workers in a more specific direction in order to include new important competences.

The basic concept is explained in Fig. 10.5.

The competences and skills required from technicians involved in maintenance of transportation systems are a blending between the actual competences of the VETs programmes on maintenance and the skills made available by I4.0 introduction. The result will be a VET focused on Maintenance 4.0 able to train and deliver workers with mechatronics skills.

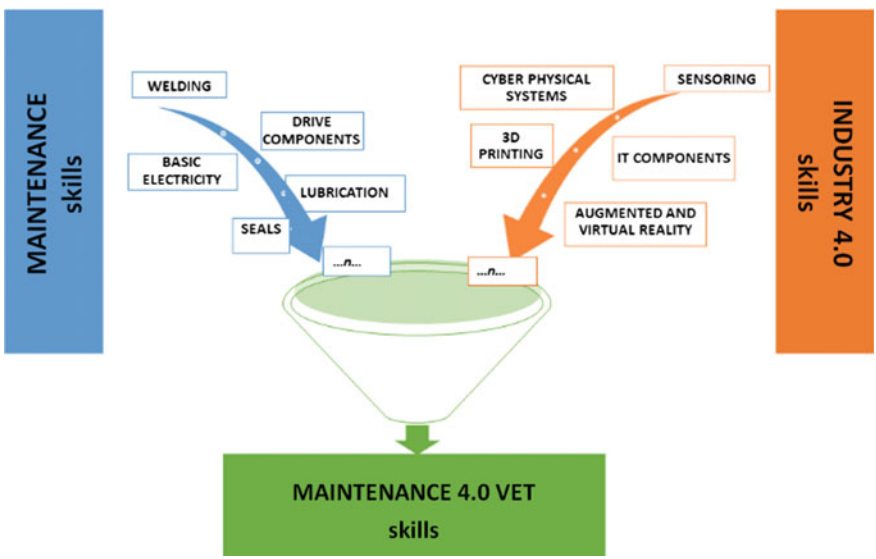


**Fig. 10.5** Maintenance 4.0 VET skills: blending of maintenance and industry 4.0 skills

## 10.4 Discussions

Besides the new contents to introduce in VETs for a better embedding of I4.0 technologies, it is important to underline how also educational methods should be adjusted. The latter is considered one of the best solutions for avoiding sensible depletion in the educational and training quality VETs programmes.

According to also to the topics highlighted and discussed in the previous sections, new educational methods such as blended learning and e-learning represent some of the important aspects to implement and to include more frequently in the future VET schools.

Therefore, it should be considered relevant for the development of successful VET programmes, the teaching of Maintenance 4.0 competences using:

- Blended Learning: It offers both distance learning and traditional learning. It encompasses different learning solutions ranging from classroom lecture, to virtual lecture for allowing self-paced e-Learning, etc.
- Self-Paced Learning: the student decides how much time he/she needs to spend on a specific topic choosing also the place where to access the courses from. Self-paced learning refers to the type of instruction that allows a person to control the flow of the courseware. It implies the learning environment is asynchronous.
- e-Learning: implies delivering e-Learning content in small units (chunks, learning snacks) for better retention and higher engagement. Mobile learning is learning based on mobility often through mobile devices like smartphones, iPads, other tablets, and wearable technology.

The reason to choose those specific methods is twofold: (i) first, the combination between traditional and at a distance lessons can offer the right mix for the students to receive enough inspiration during a face-to-face discussion with the lecturer and still benefitting of the advantage of choosing the time to listen to the lecture through different devices based on where they are. In this way, the learning process becomes more flexible and more student-oriented. Second (ii) society is on the edge of several changes. The way of communicating, the way of interacting is always more oriented to a digital revolution, especially in a technology-driven sectors. Trainers have to be part of this evolution in offering more agile and dynamic ways of learning, adopting multi-functions platform for giving the opportunity to the students to interact and discuss the contents with IT solutions.

The applications of those innovative methods can facilitate the retention of the information acquired during the VETs (Ebbinghaus 2013).

## 10.5 Conclusion

The note presented a discussion on the necessity that VET follows the technology evolution happening in the challenging field of maintenance of transportation systems. First, a definition of VET and Transportation Maintenance 4.0 is offered.

Borrowing as an example the increase of new technologies related to I4.0 introduced in the last train sets operated by NS, the chapter discusses how these changes are affecting both the way of working and the necessary competences needed to properly maintain those new systems. The competences do not only lie on the mechanical side; workers are now asked to have skills in both mechanics, electronics and IT sciences. The latter is requesting strong modifications in the learning goals of VETs, but also in the way of transferring the knowledge. New educational methods based on the concepts Blended Learning, Self-Paced Learning, e-Learning could bring benefit for improving the knowledge retention. Future researches need to be carried on these topics in order to increase the efficiency of VET in worker knowledge formation.

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