

Georg Spöttl, Siriporn Parvikam, Paryono Paryono (Eds.)

Fit for Industry 4.0 Innovative Learning and Teaching for Digitalization and Automation



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Innovative Learning and Teaching for
Digitalization and Automation

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The essence of effective training lies first of all in the determination and engagement of the private sector to provide quality training and in the self-directed commitment of the trainees to exploit this resource.

This publication is dedicated to support upgrading of skills and competencies of TVET personnel towards Industry 4.0 and Digitalization.

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Foreword

Whether in Germany or in the ASEAN region, the dynamic progress of digital technologies changes the way we produce goods and services across all industries.

In 2020 the COVID-19 pandemic accelerated the proliferation of digital technologies and further raised awareness of the transformative effects of digital technology on industries and work-processes.

To enterprises, this transformation, often labeled “Industry 4.0” or the “Fourth Industrial Revolution”, promises further increases in labor productivity and cost savings, as well as the opportunity to develop and mass produce innovative products tailored to specific customer demand.

The implications of Industry 4.0 for labor markets and the workforce have been the subject of academic analysis and discourse for several years now. A consensus seems to have emerged that considerable efforts in up-skilling and re-training are required to enable larger parts of the population to share the benefits brought by digitalization and automation.

More recently, therefore, attention has shifted to the competency requirements of Industry 4.0 and the implications for education.

Analyses of “Berufsbildung 4.0” (BIBB 2019) or “The Digitalization of TVET and Skills Systems” (UNESCO and ILO 2020) have drawn attention to necessary adjustments in the education system so that technical and vocational education and training (TVET) better prepares young people for current and future labor market requirements.

In 2018, the German government’s *Regional TVET Cooperation Programme for TVET in ASEAN* (RECOTVET), along with representatives of TVET teacher training institutions from ASEAN member states and the Regional TVET Centre of the Southeast Asian Education Ministers’ Organization, SEAMEO VOTTECH in Brunei, asked: “*What additional knowledge and which competencies do TVET teachers need to qualify students for a work environment characterized by digitalization and industry 4.0?*”

To answer this question, we were delighted to secure the expertise of Prof. Georg Spöttl of Bremen University and leading experts and practitioners from TVET institutions of the ASEAN region including the German-Malaysian Institute and the Thai-German Institute.

They have developed five in-service training modules “Fit for Industry 4.0” for the managers of TVET institutions and for TVET teachers:

- Module 1: Innovative Teaching and Learning for Industrial Changes due to Industry 4.0
- Module 2: Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0
- Module 3: Curriculum Design for Industry 4.0 Work-process

- Module 4: Quality Assurance and Quality Development in TVET Institutions
- Module 5: Industry and TVET Institutions Linkages

In pilot trainings in 2019, we were impressed to find that these trainings provide access to know-how of the nature and requirements of the “future world of work” by referencing real-life examples for representatives from all ASEAN member states.

More importantly, the trainings do not stop at an introduction to innovative systems and basic digital competencies. They allow multipliers to experience first-hand a form of teamwork in teaching and learning that is conducive to the transversal skills that are first and foremost required to succeed in a newly digitalized work environment – and to share this new know-how with others.

On behalf of the RECOTVET programme, I would like to commend Prof. Spöttl and the authors of this book for making the thinking behind the training modules “Fit for Industry 4.0” available to a wider audience. I am convinced this publication can make an important contribution to strengthening the capacities of TVET systems in their adjustment to the requirements of digitalization – in the ASEAN region and beyond.

Ingo Imhoff
Programme Director
Regional Cooperation Programme for TVET in ASEAN

Foreword

The 4th Industrial Revolution (Industry 4.0) has affected every aspect of our lives, including our world of work. The impacts of Industry 4.0 are manifold. All the working areas in a smart factory are confronted by new working opportunities offered by using Cyber Physical Systems and the changes in work-processes and work organization. Dealing with a number of different data formats, high quantities of data, cloud computing, data safety and data mining are new dimensions of work on the shop floor with which everybody is confronted.

This publication introduces the current changes based on lean production and will create a deeper understanding of the impact on skilled work, thus creating awareness of the workforce required for Industry 4.0. It will also introduce the use of different data, the different safety systems and the use of IT safety systems to make work safer. The impact and possible consequences of industrial changes because of Industry 4.0 on TVET and TVET management will be the main focus of this training programme.

With support from the RECOTVET programme, the ASEAN members have identified five state-of-the-art in-service training modules that are high on the agenda for all AMS in the era of industrial change. The training modules have been designed to support TVET trainers, lecturers and instructors in the field of digitalization through innovative teaching and learning, quality assurance and quality development in TVET as well as to maximize the competence of TVET managers of TVET institutions to keep up with the changing world.

The training of multipliers will take place in close collaboration with SEAMEO VOCTECH Regional Centre with the regional training modules integrated into the regional training programmes offered by the Centre.

The main objectives of training of multipliers are to enable participants to:

- Analyse the technological changes in teaching and learning and initiate the need for innovative teaching and learning for industrial changes;
- Build the capacity of multipliers through regional training modules Learn- and Work Assignments (LWAs), curricula and training materials developed;
- Acquire knowledge of and skills in innovative technical developments as required by Industry 4.0/ Digitalization;
- Better design, plan, organize and deliver their own in-service training modules training programmes;
- Develop the ability to use innovative teaching approaches in terms of self-reliant learning, problem solving and enhancement of communication;
- Develop the ability to make use of digital media to support learning and teaching.

After the training in 2020, around 200 TVET practitioners in the ASEAN region will have become multipliers and TVET training institutions in Brunei, Cambodia, Lao

People's Democratic Republic, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor Leste and Vietnam will have incorporated the in-service training modules in their TVET system as well as provided training on the developed modules effectively at the national level.

On behalf of the TVET community in Southeast Asia, I would like express high appreciation to GIZ-RECOTVET for this excellent and timely collaboration. I hope that you will find the modules useful. Enjoy reading!

Alias Abu Bakar
SEAMEO VOCTECH Director

Preface

“Industry 4.0 has a high potential to positively impact economic development and to contribute to the sustainable development of cities of developing countries and emerging economies. However, it is also dependent on appropriate economic and urban framework conditions in order to make its potential benefits work.” (GIZ 2014)

We are getting used to living in an age of change. This global change is probably nowhere felt more severely than in those countries of Asia which have strongly relied on technological advance in their development.

These advances have a name: digitalization.

We are witnessing digitalization as a driving force which affects all spheres of life. At its core, this driving force is based on a new paradigm of technological development which creates new perspectives for our interaction with the world around us. Consequently, human engagement with these perspectives in work has to be considered as a central issue of human development and it is up to TVET to provide humankind with the means to deal effectively with the implications of digitalization.

The aim of this booklet is to *appraise the impact of digitalization and to provide guidelines and further training concepts for TVET teacher training for coping with this phenomenon in Asian countries*. Due to the paramount scope of this task and the uncertainty of the future development involved, we intend to approach this undertaking through the following three steps:

- an overview of the potential impact of digitalization for TVET;
- a self-reliant learning concept taking account of the milestones of further training in digitalization/Industry 4.0;
- recommendations for further training actions based on modules to be followed in order to secure a humane line of development in relation to the impact of digitalization.

The participants of the training activities are teachers of TVET centres in South-East Asian countries. Within the above-mentioned three steps, multipliers will be prepared to be ready for future developments and for further training of their colleagues.

Georg Spöttl; Siriporn Parvikam; Paryono Paryono
Bremen, Bangkok, Brunei 2021

1 Introduction

We are currently witnessing a change in the world of work in terms of digitalization, calling for a review of the opportunities and risks we are facing in Technical and Vocational Education and Training (TVET). Opportunities are arising through the enhancement of qualified work and the profiling of occupations which could contribute to a stabilization and further development of the TVET systems. Risks occur due to a devaluation of occupational tasks caused by automation which could render individual occupations and tasks superfluous. Questions regarding the further development of vocational education and in particular the development of competences will be focal points of this booklet.

The world of work is currently definitely changing because of the influence of digitalization. Key terms applied extensively throughout this booklet are: Fourth Industrial Revolution, Digital Revolution, Industry 4.0, Education 4.0, Work 4.0, Occupations 4.0, Digitalization, Networking¹ and so on. All these terms can be reduced to the common denominator of *new technologies that are directly or indirectly changing the automation of action processes*, not only within the economy, but in all spheres of our lives. Amongst others, robotics, sensor technology, Artificial Intelligence (AI), assistance systems and driver-assistance systems have not been exclusively developed for industrial production but are also relevant in all imaginable spheres of life. These technologies are changing the way we act in everyday life, and – in the long term – within societal structures (cf. Spöttl 2016). This process is sometimes symbolically underpinned by the terms “service society”, “knowledge society” or even “leisure society”, often as a contrast to our established work-oriented society. Above all, this discourse assigns special significance to vocational education, because TVET provides vocational qualifications and shapes occupations. It is thus the key to coping with societal change, and for this reason the discussion about digitalization is assigned a high social and ethical significance.

After a multi-layered discussion of these terms over the past four years, a kind of consensus has been found for understanding the universally used term “digitalization” (and its variations such as “digitalization process” or “digital networking”). Although this term at first glance seems to be limited to the technological aspect of the

¹ Clear-cut definitions of these terms are not yet available. The term Industry 4.0 was coined by Kagermann, Lukas and Wahlster (2011) and communicated for the first time in 2011. The term “digitalization” can be understood as the technological dimension of Industry 4.0. Following a contrary discussion around these terms in recent years, a sort of consensus has meanwhile emerged around the universally quoted term “digitalization”. Although this term rather underlines the technological variant of the development, digitalization mentioned in this paper is understood in a sense of a “digital networking” which has both a technological and a work-oriented and societal-political orientation. Thus it allows the opening of the discourse. Digital networking thus understands that, machines, plants, products, computers, software systems and humans are intelligently linked with each other and can exchange real-time data. The advocates of this development promise above all are expecting a more efficient production and use of products and services. An example taken from private life are the so-called fitness bracelets which can only develop their full performance when linked to the Internet (cf. Becker / Spöttl 2019: 569).

development, this booklet understands digitalization in the sense of “digital networking” with both a technological but also a work-oriented and socio-political orientation, and opening up for discourse. Digital networking means that machines, plants, products, computers, software systems and human beings will be intelligently interlinked and will be able to exchange data in real-time. The supporters of this development anticipate primarily that advantages will be triggered by a more efficient production and application of products and services.

2 Development Trends of Digitalization

2.1 Character of digitalization

The process of industrialization has meanwhile been taking place for 250 years and has given rise to a frequently changing complex network of corporate-organizational and socio-institutional arrangements that deliver ample reasons for initiating technical innovations (Brödner 2016, p. 10; Plattform Industrie 4.0 2013; Reich 2015; Röben 2019). This development has been accompanied by a detailed corporate division of work, as well as by increasingly higher productivity and lower labor costs. Actual work has also changed during this process (cf. Wetzel 2015; Haase 2017; More 2019).

The core statement in this context focuses on:

- the mechanization and automation of specialized manual labor and
- the computerization of brain work (knowledge work) with the aid of algorithmic signal processing (digitalization) (cf. Brödner 2016, p. 11).

The scientification of production and automation support this process. Brynjolfsson/McAfee (2014) underpin the meaning of the term digitalization or “Fourth Industrial Revolution” by stressing that digitalization alone is not enough.

Digitalization does not only but also encompass digitally controlled physical processes equipped with interfaces to human beings (as it is the case for machine-control devices such as CNC-programmes, freely programmed control systems and drive regulations for drive systems).

What is new is the fact that a lot of these processes are horizontally and vertically networked with the internet via top-level data exchange (e.g. Internet of Things and Services, cf. Bremer 2017). Furthermore, these processes are supported by the mechanisms of Artificial Intelligence. Thus, completely new spaces for interaction between machines (e.g. multi-agent systems) as well as between human beings and machines are being created. Some examples:

- linking of products and information (e.g. via RFID-Chips),
- high velocity of information transfer (“broadband”),
- unlimited storage options (“Cloud”/“Big Data”),
- virtualization of equipment and products (“Cyber Physical Systems”),
- quick processing of a high wealth of information (“Real-Time Processing, Big Data, computer farms”),
- objects communicating among each other (“Embedded Systems”),
- worldwide availability of data and services (“Smart Technologies”).

Less technologically oriented dimensions are:

- high-velocity innovation,
- optimization and mastering of processes,
- cooperation in heterogeneous teams,
- creativity during processes of problem solving.

Hence there is more involved than digitalization in the technical sense. Brynjolfsson/McAfee (2014) have labeled this development “The Second Machine Age” while aca-tech (2013) has named it the “Fourth Industrial Revolution”.

In the framework of the paper at hand, the term “digitalization” should be understood in a way which considers Artificial Intelligence in the context of its societal effects as well as in the context of “Industry 4.0”. This is meant to underpin the special features of this form of digitalization relevant for work in the production sector.

This concept of digitalization underlines the social relevance of these developments, the changing structure of interpersonal communication, Man-Machine-Interaction and Machine-Machine-Interaction with a considerable impact on the shaping of work, on work organization, the economy, learning, necessary qualifications and occupations.

2.2 Changes in the world of work

2.2.1 The scope of digitalization

Digitalization is a contradictory process. On the one hand, digitalization is a rationalization strategy with considerable risks for employment and working conditions. On the other hand, digitalization allows for a humanization of the world of work, prevents devaluation of qualifications and could contribute to enable demanding work that is supported by learning. However, it remains to be seen whether the use of technology and differentiated work organization in digitalized enterprises will indeed pave the way for humanized work. This will depend on the orientation of the shaping of work and on the availability of the required skilled workforce. In any case, vocational education and training is a key element for accessing the potential for a humane orientation of digitalization.

The digital economy tends to increase the importance of appropriate competences as a key source of trust between producers, service providers and customers (cf. Tirole, 2016). At the same time, the digitalization of the economy and the advent of the 4th Industrial Revolution might also create important socio-economic dangers and risks that cannot be ignored when analyzing the implications of development trends and the change of needed competences. For example, the kind of competences needed are strongly influenced by the particular work organization (cf. Tirole 2016). This has a deep impact on the socio-economic balance (see Figure 1) if it concentrates on one of the three pillars of the model which is depicted in Figure 1.

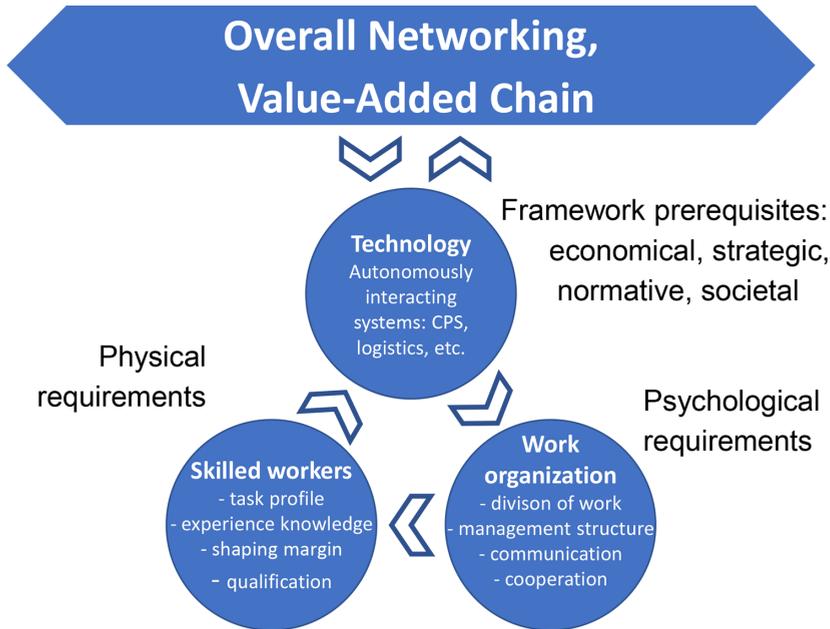


Figure 1: Socio-Technical model (Source: Hirsch-Kreinsen 2014)

Schwab (2016) indicates that the consequences of digitalization for jobs and employment depend on the interplay between the *destruction effect* which arises when the technology enhanced disruption and automation substitute capital for labor thus forcing workers to seek other fields of application for their skills, and the *capitalization effect of new jobs, occupations and businesses* created by the demand for new goods and services. According to Schwab (2016), the innovations of IT and other disruptive technologies raise productivity *by replacing the existing workforce*, rather than creating new products requiring more labor to produce them. Such development leads to a growth of employment in the high-income knowledge-intensive and creative jobs, as well as in low-income manual occupations that cannot be easily automated. At the same time, the number of middle-income routine jobs is likely to be considerably reduced (cf. Schwab 2016). This fosters increasing polarization of skills and income. In contrast, Pfeiffer (2017) notices increasing significance of skilled labor in the field of maintaining complex production processes in extensively digitalized production environments. Growing complexity of work tends to increase the significance of non-routine activities in highly automated production processes and requires subjectivization of the work procedures by holistic perception, which means to apply explorative and dialogical approaches, intuition and, empathetic attitudes (cf. *ibid.*). This statement is supported by the findings of the *baymevbm study* in the German market (cf. baymevbm 2016, Spöttl 2017).

2.2.2 Technological view of development

The 4th Industrial Revolution has been mainly described by the term DISRUPTION. It is presumed that due to multifunctional abilities of technical facilities such as

- *Cyber-Physical Systems (CPS)*, as well as the
- *support of sensor-actuator technology and platform technologies*

considerable changes will emerge in different economic sectors such as

- Industry,
- Handicraft,
- Health System,
- Education and others.

It is expected that these technological innovations will lead to a considerable optimization of work-processes in companies (cf. Ortiz et al. 2020, 13 ff.).

CPS can assess the relevant dimensions of a particular environment, and evaluate them on the basis of data which are globally available and act upon the physical world with the assistance of human agents. It is thus the intention to apply the technological means of micro-systems and information technology in order to create open and interconnected system using sensors in order to retrieve data with regard to specific situations of our physical environment, and to interpret them and make them available for internet-based services. The interconnectivity between the physical and the virtual environments in CPS leads to new dynamic production processes which were not feasible before. This can be regarded as the *fusion of physical and virtual phenomena* (see Figure 2).

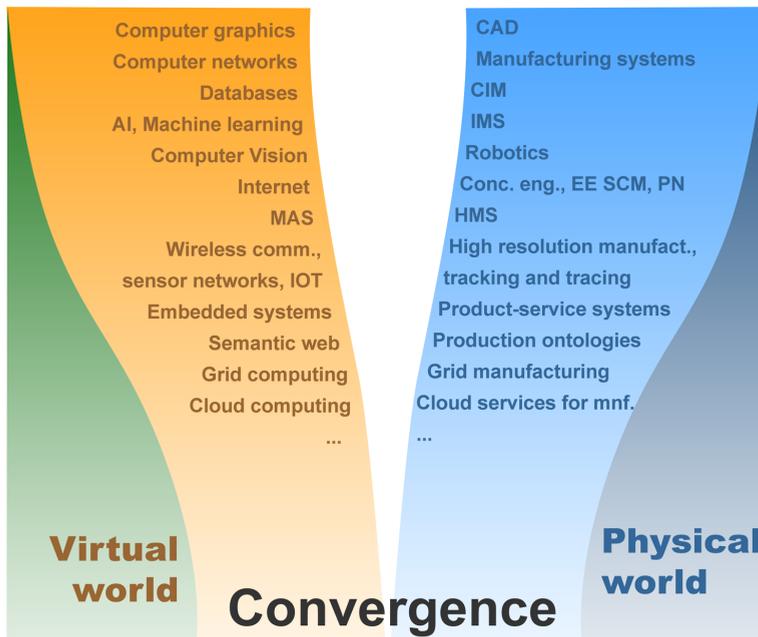


Figure 2: Convergence of the technology (Source: Monostori et al. 2016)

As one of the application fields, Industry 4.0 is based on the Internet of Things (cf. Abicht/Spöttl 2012; Spöttl/Windelband 2021). Common objects of our physical environment are thus connected with the digital world (Windelband/Dworschak 2015; Hirsch-Kreinsen 2015; Windelband/Spöttl 2013). That is why *Industry 4.0 can be regarded as the firm establishment of the Internet of Things through CPS*. However, Industry 4.0 follows a more comprehensive concept of interconnectivity which intends to assess and interrelate all steps of a process of creating values (ibid.). The “intelligence of interconnectivity” is expected to encompass the whole factory, whereby intelligent machines are supposed to organize the production processes by themselves (cf. Bauernhansel, ten Hompel/Vogel-Henser 2014; Brynjolfsson/McAfee 2014) even up to the point of taking care of the logistics involved. Hence, within Industry 4.0, humans hold the central position of directing and managing this process (cf. Figure 3).

Industry 4.0 can rightfully be referred to as a production paradigm since we have intelligent factories on the one hand and production and logistics processes on the other hand which are globally interconnected over the internet. This enables a flow of materials which can be optimized and interconnected to a degree thus far unknown.

In Germany this development has been regarded as part of the fourth wave of industrialization which is commonly referred to as the “intelligent factory” or “smart factory”.

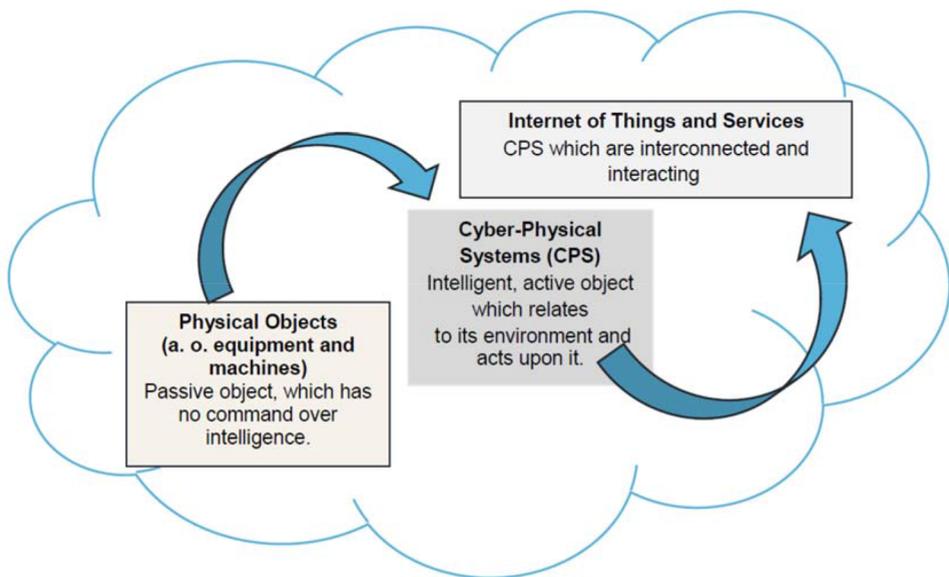


Figure 3: Digitalization: Core elements and their connectivity (Source: Spöttl/Windelband 2017)

This kind of technological development must definitely be addressed as a long-term strategic project which intends to create intelligent closed processes in production and the neighboring fields as well as finally within the entire value-added chain of produc-

tion. This calls for innovative concepts of interaction between man and machines in order to direct work-processes in the future.

Primary importance has the question of how education, training and further training should react to digitalization. From the perspective of technological development, digitalization and Industry 4.0 continue what has already played an important role in shaping the world of work and the structures of production since the implementation of computer technologies – with the first steps appearing in the 1950s and 1960s. How to react to these developments has been a permanent issue for the development of training programmes and it is likely to continue this way.

2.2.3 The digital economy and the change in the structure of work

The development of the digital economy tends to increase the importance of competence as a key source of trust between producers, service providers and customers (cf. Tirole 2016). For example, competence needs and requirements are strongly influenced by change in the work organization brought about the advent of Industry 4.0, especially the individualization and growing autonomy of work execution, as well as fragmentation of many jobs into micro-jobs (cf. *ibid.*). Digital taylorism based on standardization and subsequent digitalization of the execution of complex work-processes and “high-skilled” tasks increases replaceability of the highly-skilled workforce (cf. Brown/Lauder/Ashton 2011). The autonomy of medium-skilled and even high-skilled employees is also being contested and challenged by the increasing digital control of the execution of work tasks (cf. Tirole 2016; Reich 2015).

The 4th Industrial Revolution is also expected to challenge the stability of the structure and contents of competence. Competence will cease to be just defined through more or less stable capabilities within a profession or domain of expertise, but rather through the continuous evolvement of dynamically changing capabilities by acquiring new skills and approaches to acting in the changing variety of contexts (cf. Schwab 2016). These issues raise the following questions:

1. What is the role and place of the human factor in the future socio-economic development related to Industry 4.0?
2. What kinds of competences are needed to access and ensure decent work and employment under the conditions of Industry 4.0?

Answering the first question from the anthropological and ethical perspective leads to the assumption that the human factor should constitute the basis of socio-economic development related to Industry 4.0 (cf. Destatte 2016), as well as to the belief that people and organizations are capable and willing to use the technological and organizational possibilities offered by the technological revolution for the improvement of the quality of work and its accessibility for all (cf. Bruni 2017, Spöttl 2020).

As for the second question, many authors suggest a holistic approach of competence that enables to deal with the perspective of an unknown future. An interesting example of such an approach of competence is suggested by Mulder (2017). His competence model contains capabilities required for dealing with global openness and new

perspectives, such as abilities to analyze and assess future-oriented developments, to develop interdisciplinary knowledge and to act in an interdisciplinary way by recognizing and assessing risks, dangers and uncertainties. With these and other elements competence 4.0 enables creative solutions of the unknown problems and constant optimization of the state of customers, commissioners, citizens, co-workers, students etc. (cf. *ibid.*)². This second part of the answer guides us to long-term perspectives and activities within TVET. Yet, even under a short-term perspective, answers are necessary as to the requirements of industry. Already today and in the near future, a highly relevant question relates to identifying the kinds of competences that need to be developed.

Digitalization can be regarded as a change of paradigm which has as its main intention to enforce Industry 4.0, networking and virtualization in the companies in all areas. Consequently, next to Industry 4.0 there is an intensive industrial-political discussion about the terms Economy 4.0, Work 4.0 and Learning 4.0 (Schröder/Urban 2016). These discussions explore the possibilities enabled by an increase of digitalization. The existence of these debates shows at any rate: Regardless of the issues which are still open with respect to the effects of Industry 4.0, IT-security, the protection of data or Big Data, regarding concrete change in companies, regarding the impact of digitalization on occupations, qualifications, the world of work, mobility, productivity, safety at work and so forth, the developments supporting Industry 4.0 are politically strongly enforced (cf. Hartmann 2014).

Studies exploring the requirements of automation in work emphasize the “ironies of automation” which describe the dilemma of employees in highly automated environments. For example, employees are involved in a controlling and monitoring function, yet at the same time, due to increasing automation, they have fewer chances to completely understand the ongoing processes. However, insight is needed to acquire the necessary experience for the solution of problems (Brainbridge 1983). All in all, it has to be assumed that employees working in the production process will continue to play an important role in many fields. Questions which call for clarification in this respect are as follows:

1. How will employees interact with the new interrelated world of production, which according to all reports can be expected to be more intelligent than the present settings?
2. Which kind of change will the profiles of qualification and competence undergo?
3. Why is this likely to happen? What are the most important and determining factors of influence for the design of networking processes?

It is evident that these innovative technological structures will considerably influence the design of production processes. The translation of complicated and complex “structures of machining” into the digital and virtual operation of machine tools will change work-processes, since “dangerous”, “very difficult”, “dreary” or “easily executed” tasks can be taken over by automated machines. These developments are not

2 A more precise definition of “competence 3.0” is not available in the literature.

altogether new, yet their introduction brings about change regarding the task-profiles to render them more or less demanding (Hartmann 2015), since human beings and machines can work together through different interfaces. There is a tendency that more and more parts of work-processes currently carried out by human action are being taken over by machines. This has a considerable impact on the actions of the employees involved in this process and will require a high capability of abstract thinking from them (cf. Markowitsch et al. 2008). For vocational education it is important to decode these developments (cf. Spöttl/Windelband 2021).

2.2.4 Selected studies and analytical material

2.2.4.1 Development of jobs in highly discussed studies

One of the most discussed studies on digitalization/Industry 4.0 seems to be the Frey/Osborne (2013) forecast of the impact of digitalization on jobs. Based on the analysis of American job profiles, they concluded that around 47 percent of total US employment will be at risk within the next 20 to 30 years due to Industry 4.0 (ibid.). In 2016, the World Economic Forum noted that:

“Current estimates of global job losses due to digitalization range from 2 million to as high as 2 billion by 2030. There is great uncertainty about the overall impact of digital transformation of jobs, with concerns also about its impact on wages and working conditions” (Schwab 2016).

In Germany, more cautious positions have been formulated:

- “Replacement of workers can’t be observed – even though Germany has the third highest density of robots worldwide – but new kinds of working organization with new and higher challenges of man-robot-collaboration are coming – with increasing numbers of jobs – but in newly formed qualification requirements” (VDMA 2016).
- The baymevbm-study (cf. baymevbm Studie 2016) noted that the introduction of Industry 4.0 in the metal and electrical industry will create between 20 and 30 percent of new workplaces in the segment of highly qualified skilled workers, master craftsmen, semi-engineers – ISCO 3 and 4.

The situation regarding the German labor market differs from the Anglo-Saxon labor market (also due to the different structures of the educational and employment systems). This has been underpinned by the surveys of Dengler/Matthes (2015 and 2018). Their survey applied a research approach oriented at German structures and focused on the substitution potential of digitalization based on the expert data base BERUFENET of the Federal Agency of Employment for the year 2013 (cf. Dengler/Matthes 2015, p. 4). The authors concluded that just 15 percent of the employees who are subject to statutory welfare contributions must be prepared for a high substitutability. The more recent study revealed (2018, p. 10) that a quarter of employees who are subject to statutory welfare contributions are working in occupations where at least 70 percent of the daily work tasks could be managed by computers or computer-aided machinery. The authors underline once more what is technically feasible and relativize the still

open questions regarding the development of employment in occupations. The authors also give an important hint that occupations are changing more slowly than the potential fields of application of new technologies. Their recommendation: “All occupations should be continuously monitored as to whether their task profiles are still meeting the latest technological requirements” (Dengler/Matthes 2018, p. 10).

The result of a study by Bonin/Gregory/Zierahn (2015, i) is also very interesting. The researchers are working with an alternative research approach (compared to Frey/Osborne 2013) and come to the conclusion that 9 percent of the US-American work places show a relatively high probability of automation compared to 12 percent in Germany (cf. Bonin/Gregory/Zierahn 2015, 14). These results are more or less in line with the findings of Dengler/Matthes (2018).

2.2.4.2 Jobs at risk in ASEAN countries

Digitalization is expected to have a deep impact on automation. Automation itself meanwhile exerts a massive influence on employment and the size of the workforce needed. Digitalization facilitates the automation of work-processes. On the following pages, several studies are evaluated which try to answer the question of how automation is influencing the individual ASEAN countries.

Study No. 1 (Chang & Huynh 2016):

Interrelationship between jobs and routines:

- *Because developing and emerging economies often engage in singular or less diverse economic activities and also have a larger workforce in low-skilled employment with low educational attainment levels, preventive and proactive steps must be taken to avoid substantial parts of the workforce losing their jobs (p. 14/2)³.*
- *Occupations in which the bulk of tasks are more routines and follow explicit, codifiable procedures tend to be more adaptable to automation [...]. By contrast, jobs resistant to computerization involve extensive non-routine, abstract tasks that require judgment, problem-solving, intuition, persuasion and creativity [...]. Jobs that also resist automation are those with non-routine, manual tasks that demand a high degree of situational flexibility and human interaction (p. 18/6).*

Table 1 establishes an interrelationship between jobs/occupations, routines, non-routines and skills levels. It is noticeable that academic professions such as doctors and lawyers are counted among jobs with high requirements whereas cashiers and typists are assigned to the other end of the scale.

3 First number: page numbers according to “.pdf file”; second number: page numbers according to “manuscript file”.

Table 1: Interrelationship between jobs/occupations, routines, non-routines and skills levels (Source: Chang/Huynh 2016)

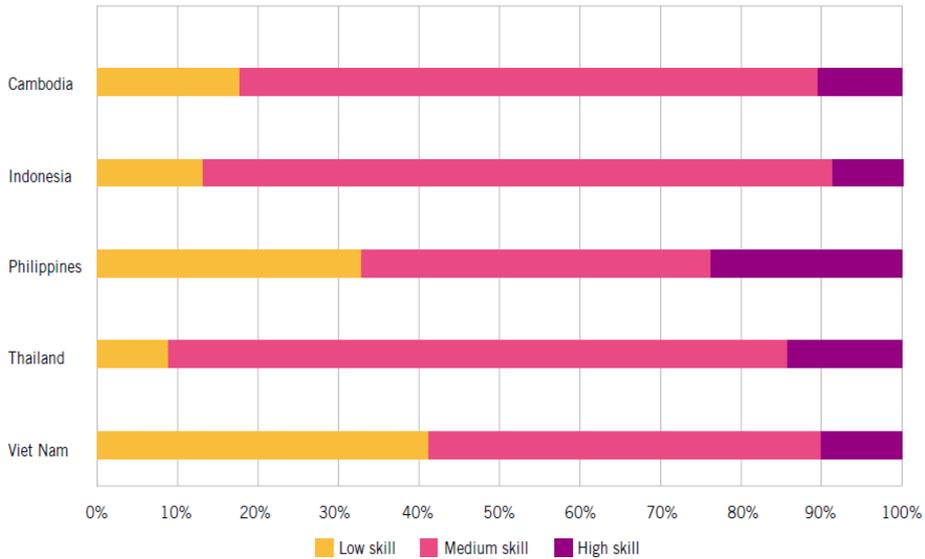
		Ease of automation	
		High (Routine tasks)	Low (Non-routine tasks)
Ease of complementarity	Low (Manual-intensive skills)	Cashiers Typists Machine operators	Landscapers Home health aides Security personnel
	High (Cognitive-intensive skills)	Bookkeepers Proofreaders Clerks	Doctors Lawyers Managers

Creative intelligence, social intelligence, and perception and manipulations are noted as the three non-automatable tasks as follows:

- *Perception and manipulation tasks:*
 - (1) *Finger dexterity*
 - (2) *Manual dexterity*
 - (3) *Cramped workspace, awkward positions*
- *Creative intelligence tasks:*
 - (4) *Originality*
 - (5) *Fine arts*
- *Social intelligence tasks:*
 - (6) *Social perceptiveness*
 - (7) *Negotiation*
 - (8) *Persuasion*
 - (9) *Assisting and caring for others (p. 19/12)*

The authors found out that a lack of skilled workers with proper technical and digital competences exists in a number of ASEAN countries. This is outlined in *Figure 4*.

Skill level



Low skill = ISCO 9 (elementary occupation)

Medium skill = ISCO 4, 5, 6, 7, 8 (clerks, service staff, craft workers, operators)

High skill = ISCO 1, 2, 3 (managers, professionals, technicians)

Figure 4: Distribution of employment by skill level (percent) (Source: Chang/Huynh 2016)

Selected findings of the study regarding skill needs highlight the following:

- *We need people who can troubleshoot and problem solve using new technology; however, these skills are currently difficult to source at the local level (p. 28/16);*
- *[...] higher education and training help develop the competences needed for complicated tasks requiring advanced levels of perception and manipulation, creative intelligence, and social intelligence – the tasks considered difficult to automate (p. 32/20);*
- *Among the countries examined, about 90 percent of Cambodia's workforce do not have a secondary degree. In Viet Nam, this figure is around 75 per cent, and in Indonesia and Thailand, it is about 67 percent (p. 34/22);*
- *By 2020, on average, more than a third of the desired core skill sets of most occupations will be comprised of skills that are not yet considered crucial to a job today (p. 37/25);*
- *Stronger policy commitments and accelerated coordination efforts are especially needed to foster greater cognitive, creative and social intelligence skills within the five ASEAN countries examined in this paper, as 56 percent of current workers are facing a high risk of automation (p. 37/25).*

The low qualification level points at a close interrelationship with workplaces which are subject to a high risk of automation:

Prominent occupations in certain countries face extreme risks of automation. For example, in Cambodia, where garment production dominates the manufacturing sector, close to half a

million sewing machine operators are facing a high automation risk. In Thailand, the automation risk is particularly acute for approximately 1 million shop assistants. In Indonesia, about 1.7 million office clerks are highly vulnerable by automation.

This high number is relativized by interpretation and a reference to low wages. It is presumed that low wages can thus act as a brake against the computerization of workplaces.

Study No. 2 (ILO 2016c):

One of the important statements in the study is:

- *Enterprises in ASEAN value technical knowledge, teamwork and communication as the most important skills among workers. Strategic thinking and foreign language skills are reportedly most difficult to find. Services firms tend to value university degrees much more than technical vocational and educational training (TVET) qualifications, though manufacturing firms rank them equally (p. 14/xii).*

Statistical findings show the position of enterprises in relation to their need for qualified personnel (cf. Table 2).

Table 2: Key findings from ASEAN enterprise survey (Source: ILO 2016c, p 17/xv)

Percentage	Comments
12.5 %	say they lacked highly skilled workers to make use of new technology
40.0 %	say technical skills are the most important skills, followed by teamwork and communication skills
No figure	Strategic thinking, problem solving, foreign languages and technical skills are the hardest to find

When asked for the reasons behind this lack of competences, stakeholders explained that the ASEAN region is a “taker” of technology rather than its “maker”.

Further statements underpinning a lack of skills and high skills (Figure 5):

- *Upgrading skills stood out as a recurrent theme throughout stakeholder responses. Many reported that technology drove up the skills required within the workplace. In the future, this challenge could be exacerbated. Indeed, skills shortages and mismatches remain an ongoing challenge worldwide. In 2020, the global labor market will face a potential surplus of 95 million low-skilled workers and a potential shortage of approximately 38 to 40 million high-skilled (or college-educated) workers (p. 36/18).*
- *Managers frequently experience difficulties finding talented workers for various reasons: scarce labor supply, insufficient technical competences, lack of experience and lack of soft skills (ManpowerGroup 2015). Having a skilled, educated and adaptable workforce has become so important that managers and CEOs in 83 countries reported it as being the most important outcome of society (p. 36/18, cited from PwC 2016).*

- Employers in ASEAN face shortages of hard skills and soft skills. Hard skills include English language proficiency, computer related skills and other technical skills; soft skills include time management, interpersonal communication, creative thinking, teamwork and leadership. Soft skills such as teamwork, decision making, independent communication and cooperation, among others, are increasingly in high demand in the manufacturing enterprises of developed countries (p 36/18, cited from Handler/Healy 2009).
- This was identified as most important by a higher proportion of manufacturing compared to services enterprises, though neither group found this skill more difficult to find. Services enterprises tended to place more importance on communication skills and university qualifications though, again, they and manufacturing enterprises found these equally difficult to find. Manufacturing enterprises placed equal importance on university qualifications as on TVET qualification. (p. 39/21).
- Several interviewees in Cambodia, Malaysia and Thailand highlighted English language skills as a key factor for business success, both within the ASEAN Education Council (AEC) and worldwide. Interviewees in Thailand named strong critical skills among the youth and a culture of lifelong learning among all workers as necessary for developing a world-class labor force in ASEAN (p 90/72).
- Currently, technology is driving up enterprises' demands for technically skilled workers, who are increasingly difficult to find (p. 97/79).

Which types of skills are currently the most critical for your enterprise?

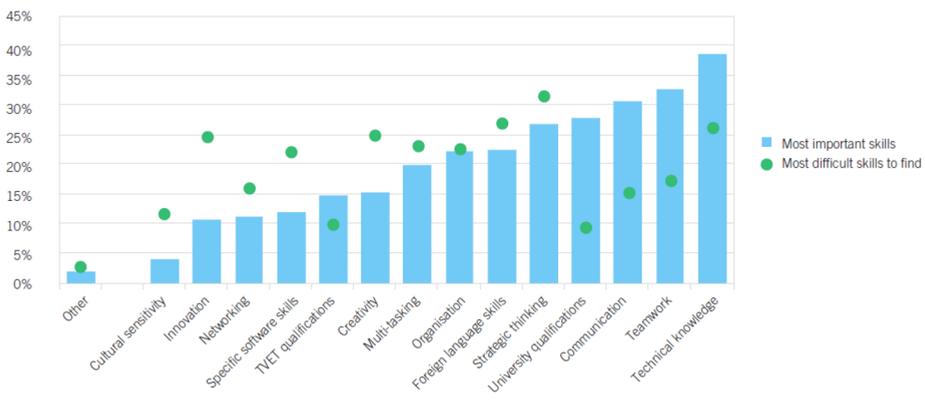


Figure 5: Shortage of skills in enterprises (Source: ILO 2016c)

- ASEAN's young people reportedly prefer white-collar jobs over manual ones. Many express the desire to become an employer or entrepreneur rather than to work for someone else. They also want more of a work-life balance compared with older generations. Above other factors, young people desire freedom in their work because of their resourcefulness and overwhelming access to information and learning opportunities. [...] Many desire

work that is at once fun, meaningful and challenging, and many want to make a positive change (p. 42/24).

- *Increased automation and robotization will displace certain occupations, especially lower skilled jobs, and in parallel, enhance the complexity and skills-intensity of existing jobs while creating new ones (p. 97/79).*

Study No. 3 (McKinsey 2017):

The McKinsey study is geared at the global market. Looking at the current dramatic change in the industrial world of work, they have gained the following insights:

- *All workers will need to adapt, as their occupations evolve alongside increasingly capable machines. Some of that adaptation will require higher educational attainment or spending more time on activities that require social and emotional skills, creativity, high-level cognitive capabilities and other skills relatively hard to automate (p. 8).*
- *Mid-career job training will be essential, as will enhancing labor market dynamism and enabling worker redeployment. These changes will challenge current educational and workforce training models, as well as business approaches to skill-building (p. 8).*
- *We estimate that as many as 375 million workers globally (14 percent of the global workforce) will likely need to transition to new occupational categories and learn new skills, in the event of rapid automation adoption (p. 11).*
- *For advanced economies, the share of the workforce that may need to learn new skills and find work in new occupations is much higher: up to one-third of the 2030 workforce in the United States and Germany, and nearly half in Japan (p. 21).*
- *The skills and capabilities required will also shift, requiring more social and emotional skills, and more advanced cognitive capabilities, such as logical reasoning and creativity (p. 25).*
- *Mid-career retraining will become ever more important as the skill mix needed for a successful career change. A range of initiatives in countries from Sweden to Singapore may point the way to new approaches to improving skills or teaching new ones, including to older workers (p. 29).*
- *Programmes that can more quickly retool the labor force by focusing on re-training and credentialing at the level of skills in demand rather than multi-year degrees could be important (p. 29).*
- *Business can take a lead in some areas, including with on-the-job training and providing opportunities to workers to upgrade their skills, both through in-house training and partnerships with education providers. (p. 29)*
- *Our analysis of how automation will affect skills suggests that workers of all skill and educational levels will be affected (p. 62)*
- *Nearly all jobs will involve a shifting mix of tasks and activities (p. 87).*
- *Within occupations, the mix of activities and the capabilities required will skew towards more personal interaction and more advanced levels of cognitive capabilities (p. 87)*
- *Work activity will shift to human interaction and working in unpredictable environments and will also require increasing application of expertise (p. 87).*

- *Increasingly across occupations, workers will be valued for strong interpersonal skills and advanced reasoning. As these skills are often developed through guided experience, workers will likely spend more time being coached in apprentice-like environments (p. 91)*
- *The workers of the future will still need to apply expertise and judgment, so training to promote fluency with and understanding of information will remain important (p. 91).*
- *As many as 375 million individuals around the world will need to switch occupational categories. Providing retraining opportunities at scale will be imperative (p. 100).*
- *Providing job retraining and enabling individuals to learn marketable new skills throughout their lifetimes will be a central challenge for some countries over the next decade and beyond (p. 116).*
- *[...] hundreds of millions of people will likely need to find new jobs as automation advances, and even more will need to learn new skills, including how to work seamlessly with machines (p. 116).*
- *Curricula will need to be adapted to provide students with the skills necessary for a dynamic, technology- and increasingly service-oriented labor market, particularly in countries and industries where automation technologies are likely to be adopted most quickly (p. 123).*
- *Lifelong learning has long been talked about reverentially in policy circles, but the new age of automation will be the time when its large-scale application will be needed more than ever (p. 134).*
- *Automation has the potential to raise productivity growth and GDP growth, but our analysis reveals that a key factor in whether this will be achieved without large adverse effects on employment and wages is how quickly displaced workers are reemployed in other jobs (p. 65).*
- *Increased spending on technology will create demand for 20 million to 46 million additional workers (55 percent direct and 45 percent indirect) globally, net of automation. They will be a mix of high-skill workers such as software engineers and electronics engineers as well as medium-skill workers including web developers and electronics technicians (p. 70).*
- *Jobs in unpredictable environments – occupations such as gardeners, plumbers, or providers of child- and elderly care – will also generally see less automation by 2030, because they are difficult to automate technically and often command relatively lower wages, which makes automation a less attractive business proposition (p. 16).*
- *In advanced economies, occupations that currently require only a secondary education or less are witnessing a net decline from automation, while those occupations requiring college degrees and higher are growing (p. 25).*
- *Moreover, we think that workers of the future will spend more time on activities that machines are less capable of, such as managing people, applying expertise, and communicating with others. They will spend less time on predictable physical activities, and on collecting and processing data, where machines already exceed human performance (p. 25).*

- *For policy makers, business leaders, and individual workers the world over, the task at hand is to prepare for a more automated future by emphasizing new skills, scaling up training, especially for midcareer workers [...]. (p. 30)*
- *[...] physical work in a predictable environment, or data collection and processing are likely to be the most relevant [...]. (p. 40).*

Study No. 4 (ILO 2016a):

The study deals with different sectors of industry with a view to skill needs. The central findings are as follows:

- *[...] manufacturers will increasingly seek higher-skilled talent with R&D competences, ranging from analytical experts to autonomous driving engineers and sustainability integration experts (p 20/xvii).*
- *Recruiting higher skills remains a challenge for employers, necessitating efforts on several fronts to address this skills gap. Education and vocational training institutions must revamp their curricula and build stronger alliances with the sector to provide a pipeline of highly-skilled workers (p 20/xvii).*
- *Currently, people exceed the capabilities of robots in overall assembly, perception, flexibility, dexterity and adaptation to new duties, which means human workers are (for now) more cost-effective. However, this is changing. Compounded with predicted up-takes in 3D printing, displacement – particularly of lower skilled packaging and assembling jobs – is possible (p 22/xx).*
- *To remain competitive, industry players (in textiles, clothing and footwear, (TCF)) must accelerate partnerships with educational and training institutions to groom the next generation of TCF workers who have stronger technical qualifications, expertise and the ability to work seamlessly with multiple strands of emerging technologies (p. 24/xxii).*
- *KPO [knowledge process outsourcing] services will further raise the skills requirements of the sector. Credentials in medicine, business, law, finance, accounting, and data analysis, among others, will be sought to provide higher value and sector-specific solutions (p. 26/xxiv).*
- *Additionally, an increase in the use of cloud technologies, big data analytics and the Internet of Things - IoT will intensify hiring demands for technically capable workers in areas such as data analysis, programming and supply chain management (p. 28/xxvi).*
- *The automotive and the Electric and Electronic (E&E) sectors will need higher-skilled technicians and engineers capable of managing new automation processes, as workers increasingly work alongside collaborative robots (p. 32/2).*
- *The retail sector will more frequently use sophisticated sensors and tags to track goods and manage stock. As a result, the demand for higher-skilled workers who can service IoT technology and run data analytics will grow (p. 33/3).*
- *It is up to us to get used to a different paradigm and focus on upgrading our skills and maintaining our versatility and adaptability (p. 35/5).*
- *Among the skills considered the most important, the most frequently cited was*

- *technical knowledge: named by almost 40 percent of respondents. Teamwork and communications skills were also viewed as highly important. Among the skills considered the most difficult to find, topmost were strategic thinking and problem solving, followed closely by foreign language skills, technical knowledge, and soft skills such as creativity and innovation (p. 36/6).*
- *It is imperative that the current workforce be open to skills and*
- *capabilities upgrading. Carrying out this recommendation, admittedly, may prove difficult, as the current quality of TVET and of other institutions with similar courses is of concern. In general, we see rote learning, outdated curricula and a lack of certification frameworks. Overall, this culminates in education systems that are unresponsive to a fast-changing sector (p. 69/39).*
- *As more factories move to automation and robotics, the availability of higher skilled labor is becoming more important, as it will drive investment decisions (p. 70/40).*
- *Modern technology such as automated cutting and CAD will increase the demand for skilled workers knowledgeable in operating new machines and in computer software (p. 86/56).*
- *ASEAN's factories are likely to turn to graduates from reputable vocational training institutions. Such recruitment will provide factories with higher skills workers who can work with modern technology and consumer needs (p. 87/57).*
- *When interviewees were asked to assess the skills needed in the workforce, data management and tech-savvy employees topped the list. [...]. Employees who can conduct data and web analysis will be increasingly sought after (p. 108/78).*
- *Digital marketing and social media skills are also often cited as skills in demand (p. 108/78).*
- *Respondents also cited the need for soft skills. [...] Time management, problem solving, and interpersonal communication are all examples of soft skills that can affect job performance (p. 108/78).*
- *Lastly, participants stated that employees needed to have more in-depth product knowledge (p. 108/78).*

Study No. 5 (ILO 2016b):

Jobs at risk of automation

- *In ASEAN countries, 56 percent of all jobs are at a high risk of automation due to developments in Industry 4.0 while 32 percent are at middle risk and 12 percent are at low risk.*
- *Jobs with manual-intensive skills at high risk of automation are cashiers, typists and machine operators, while landscapers, home health aides and security personnel are at a low risk.*
- *Jobs with cognitive-intensive skills at a high risk of automation are bookkeepers, proofreaders and clerks while doctors, lawyers and managers are at a low risk.*
- *Jobs with routine tasks which follow explicit, repetitive procedure are more adaptable to automation, in contrast to jobs with extensive non-routine, abstract tasks that require*

judgment, problem-solving, intuition, persuasion, or a high degree of situational flexibility and human interaction.

- *Cloud computing, software automation and knowledge process outsourcing have significant implications for the 600,000 workers in call-centers which face a high risk of automation at 89 percent.*
- *ASEAN's retail industry is the least threatened by up-and-coming technologies due to the fact that disruptive technologies in retail are yet to achieve mainstream usage in the region.*

Technology

- *3D-printing, body scanning technology, computer-aided design, wearable technology, nanotechnology, sustainable/environmentally friendly manufacturing and robotic automation are disruptive technologies globally.*
- *In ASEAN countries, robotic automation is the greatest threat to workers.*
- *Electrification of vehicles and vehicular components, advancements in lightweight materials, autonomous driving, and robotic automation are the four major technologies that are shaping Industry 4.0 in the automotive sector.*
- *3D-printing, body scanning technology, computer-aided design (CAD),*
- *wearable technology, nanotechnology, environmentally friendly manufacturing*
- *techniques, and robotic automation are the seven major technologies that are shaping Industry 4.0 in the textiles, clothing and footwear sector.*
- *Cloud computing, software automation and knowledge process outsourcing are the three major technologies that are shaping Industry 4.0 in the business process outsourcing sector.*
- *The process of manufacturing different components and then assembling them will be replaced by singular, onetime printing during the implementation of Industry 4.0.*

Skills

- *The skills that are most important for occupations in Industry 4.0 are technical knowledge, teamwork, communications skills, strategic thinking, problem solving, foreign language skills, creativity and innovation.*

Study No. 6 (Deloitte 2016):

This Deloitte study summarizes the developments in ASEAN countries into three fundamental trends:

1. *Ageing workforce: as the baby boomers continue to retire, they are taking key knowledge with them, increasing the need to capture their knowledge.*
2. *Information overload: information is still growing at exponential rates and employees can't find what they need, even with technology advances.*
3. *The need for speed: with the rapid pace of today's work environment, employees increasingly need to work faster and collaborate more effectively to get their jobs done (p. 5/3).*

For tackling in particular the requirements of number 2 and 3 above, the following solutions are in process:

- [...] information workers prefer newer communication tools, particularly instant messaging, over more traditional ones like e-mail or team workspaces (p. 6/4).
- The digital workplace is all about the employees' ability to do their job by collaborating, communicating and connecting with others. The goal is to forge productive business relationships within and beyond natural work groups and to enable knowledge sharing across the organization (p. 7/5).
- Collaboration: to solve business problems and operate productively, organizations need the ability to leverage knowledge across the enterprise with online, seamless, integrated and intuitive collaboration tools that enhance your employees' ability to work together.
- Communications: as information continues to grow at an unprecedented rate, more tools exist that enable people to create their own content, rather than simply consuming existing content (p. 8/6).

Training and certification:

- Ensure employees have access to training that allows them to harness the digital workplace to their advantage. Also track and ensure that technical personnel are trained and certified to properly support the underlying technology (p. 10/8).

Policy training:

- In addition to technical training, employees need policy training on the type of information they should or should not share in the digital workplace. It is also vital to communicate policies on how to properly handle personal data and how to avoid damaging the organization's brand (p. 10/8).

The instruments that are being used to deal with the requirements are explained in Table 3.

Table 3: Detailed instruments to tackle the tasks (Source: Deloitte 2016, p. 9/7)

Messaging	Productivity	Collaboration	Communication
Provides a fast way to communicate with colleagues - E-mail - Instant messaging - Micro blogging - Mobile messaging	Enables knowledge workers to get their jobs done efficiently - Word processors - Spreadsheet software - Presentation software - Calculator	Enables employees to work with each other and with partners - Team rooms - Communities - Wikis - Web conferencing	Supports information sharing and internal publishing - Portals / Intranet - Blogs - Personalized Homepage
Business applications	Crowd sourcing	Connectivity	Mobility
Enables employees to access self-service applications online - Expense claims - HR systems - ERP - CRM	Enables organization to gather ideas, inputs and thoughts from employees - Ideation platform - Polling - Survey - Forums	Helps locate experts and colleagues across the organization - Employee directory - Organization chart - Rich profile	Enables access of tools away from the physical office or workplace - PC / laptop - Mobile / smart Phone - Home office - Remote scanners

2.2.4.3 Risk of development

Various studies are currently discussing the risk of a loss of workplaces threatened by automation and therefore likely to be eliminated. Table 4 below has been generated from the findings of the McKinsey (2017) study.

Table 4: Potential of automated work activities by 2030 in hours (Source: McKinsey 2017)

Country	Automated activity hours (increase)		Million displaced jobs mid-point scenario
	% mid-point scenario	% rapid scenario	
China	16	31	118
Germany	24	47	9
India	9	19	57
Japan	26	52	16
Mexico	13	44	39
USA	23	44	39

Mid-point scenario = percent of total working hours lost to 2013;

Rapid scenario = percent of total working hours lost to 2030.

A considerable automation potential with a major loss of workplaces is predicted for the selected countries. It is also presumed that new jobs will be created. However, a considerable share of employees either needs to switch or be requalified for new jobs. These developments are not only confined to Asian countries but also concern other countries in the world. As for the ASEAN countries, the McKinsey study (2017) draws interesting conclusions:

- Analysts have suggested “the end of cheap China” and because of this, ASEAN can scoop up low-skilled work (e.g. p. 26/12).
- Full automation is not always preferable. This means that cheap labor will primarily drive ASEAN’s E & E (Electric & Electronic) sector (e.g. p. 27/13).
- In the short term, developing and emerging economies will continue to attract investment in lower-skilled activities such as packing and assembling. However, in the medium to longer term, these jobs will be automated (cf. p. 30/16).
- Low-skilled workers will be required less and less as robots are becoming more efficient and advanced. Eventually, these workers will encounter the risk of being displaced (cf. p. 31/17).

The McKinsey study (2017) identified a very interesting direction of argumentation relevant for the ASEAN countries: “The end of cheap China”. This could offer a chance to invest more in technology in order to become more competitive. At the same time, this situation could be an opportunity for weaker ASEAN countries to offer low-value production with low-skilled workers. It could be argued against this position that low-

value production will only prevail in the short-term. In Indonesia, the Philippines, Thailand, and Viet Nam, over 60 percent of the salaried workers are running a high risk due to automation.

In summary, digitalization aimed at automation can have similar consequences:

- low-skilled workers are always subject to replacement;
- on the other hand, countries are confronted with the challenge to requalify low-skilled and skilled workers in order to enable them to take over new tasks.

The only difference between the countries is the level of concern and this depends on the individual industrial structure and the degree of available technologies.

2.3 Need for competences

There is a high risk of displacement from the technological perspective. According to the findings of Chang/Huynh (2016, p. 16/4) “approximately 56 percent of all employment in the ASEAN countries will be at high risk of displacement due to technology over the next decade or two”. Drivers for displacement are prominent industries with a high capacity for automation, such as hotels and restaurants, wholesale and retail trade, construction and manufacturing (ibid.). Industries with a low automation risk are education and training, health and social work (ibid.). Women are more likely than men to be employed in occupations at high risk of automation (ibid.).

Another argumentation line focuses on new jobs to be created due to the progress in new technologies, e. g. autonomous driving (cf. ILO 2016a). New jobs will be created at a notable rate particularly for:

- data analysts,
- analytical experts,
- autonomous driving engineers,
- interaction designers,
- operators and service personnel for machines,
- troubleshooting personnel in case of malfunctions.

2.3.1 Competences from the perspective of technological change

The examples of jobs named so far concentrate on higher and medium-level occupations rather than on low skills. There seems to be practically no need for low skills.

The analyses of ILO (2016a) and Chang/Huynh (2016), both based on interviews within enterprises, describe in detail that the changed requirements point to the following emphases:

- critical thinking,
- problem-solving skills,
- strong technical skills.

This is why representatives of the manufacturing sectors are supporting the education and training of technicians and highly skilled engineers (cf. ILO 2016a; Chang/Huynh 2016).

A comparable line of argumentation is pursued by the OECD based on a literature analysis:

- Digital technologies are replacing workers in performing routine tasks and increasing demand for non-routine ones.⁴
- Such shifts in the relative importance of tasks to be fulfilled at the workplace raise questions: Which skills should workers develop in order to meet the new requirements of work? (OECD 2016, p. 9).

From these analyses, stakeholders have drawn the following conclusions can be drawn:

A profound transformation of the economies and the world of work is currently taking place (disruption), calling for skills oriented to this change and an increasing amount of knowledge.

“Workers in the digital economy should be able to:

- generate and process complex information;
- think systematically and critically;
- make decisions by weighing up different forms of evidence;
- ask meaningful questions about different subjects;
- be adaptable and flexible to new information;
- be creative; and
- be able to identify and solve real-world problems” (Baymevbm 2016).

These requirements do not create a demand for new skills but rather increase the importance of some human competences that have been valuable for several decades.

2.3.2 Competences from the perspective of work change

Digitalization will result in more opportunities for computer-based automation and robotic systems to replace as well as complement human workers both in the production and service industries. In order to drive the transformational opportunities promised by Industry 4.0 and create value from automation, organizations need to consider developing their future workforce with competences aligned to industry-specific requirements. Rapid and extensive automation of business processes together with the emergence of novel business models impose new skill requirements for the workforce. Indeed, further adoption of digital systems along with successful implementation of Industry 4.0 require an even wider range of employee skills due to increased complexity of work environments with new operational and organizational structures. Consequently, roles of employees will change in terms of content and work-processes, and these changes will require significant transformations in jobs and skill profiles of employees.

4 More important than ever in the face of the Corona/Covid 19 Pandemic.

Some statements revealed that by 2020⁵ more than one-third of the desired skill set of most jobs will be comprised of skills which are not yet seen as important (cf. World Economic Forum 2016). More surprisingly, 65 percent of today's children will do jobs that haven't even been developed yet (cf. OECD 2016). According to 2020 predictions of the World Economic Forum (cf. World Economic Forum 2016), the future workforce is expected to have mostly cognitive abilities (52 percent), systems skills (approximately 45 percent), and complex problem-solving skills (40 percent). In addition to those skills, workers are required to have basic skills in information and communication technologies (ICT). In line with increased automation and digitalization of work-processes, organizations depend more on employees with ICT specializations who can analyze Big Data, make coding, develop applications, and manage complex database networks (cf. Karacay 2018, p 126 f.).

Based on the empirical work of the European project Auto 4.0, the following competences were generated:

- broad competences (as “new basics”);
- context-specific competences I and II; and
- “abstract” competences.

These competences are listed in Table 5. Based on these competences the project group has identified generic competences (Table 5) which form the basis for the development of learning assignments for the European Core Profile “Automotive Digital Mechatronic X.04”.

Table 5: Different type of competences relevant for skilled and highly skilled workers (cf. Spöttl 2020)

The “New Basics” – Broad Competences
Learn to think starting from the software; Get to know network structures; Learn how to master Big-Data technologies; Learn how to work with a variety of data formats; Understand and master processes; Learn how to take on more self-responsibility; Learn how to cooperate and communicate better; Learn how to initiate innovations; Learn how to use clouds, integration of various machine data/manufacture data; Understand and consider the environmental and social impact of technology choices and innovations; Learn to use data as ‘raw material’, how to use it and to attach more importance to it; Make use of innovation potential; Support shaping competence.

5 The argumentation nowadays is going into the same direction in almost all relevant publications.

(Continuing Table 5)

Context Specific Competences
<p>In plant operation, however, it is important that workers develop further in the following areas of competence:</p> <ul style="list-style-type: none"> • Problem solving; • Understanding of integrated systems and their interconnections; • Linking of different system controls; • Thinking and working across disciplines; • Getting involved in new tasks; • Application of IT technology as a tool; • Necessity to think through the processes, to master processes; • Mastering multifunctional plant operation; • Working in the delimitation of space and time; • Consideration of the entire value chain; • Maintenance, monitoring, care of drive technology; • Third hand' (e. g. lightweight robots) will gain importance in the industrial context.
“Abstract” Competences
<ul style="list-style-type: none"> • Creativity, creation, critical thinking; • Communication, collaboration (in teams); • Modeling skills, analytical spirit; • Data gathering & mining; • Respect of procedures; • Relational communication skills, investigative character; • Lateral thinking, curiosity; • Leadership, innovative management; • Vision and communication; • Understand business problems.

The need for qualification initiatives is also emphasized by the ILO-studies (cf. Rynhart/Chang/Huynh 2016):

- The studies demand skills upgrading in order to keep the industry competitive in the long-term (ibid. p. 27/13).
- Furthermore, higher-value production and higher skilled assembly work must be established (ibid. p. 28/14).

In particular, the following is required:

- *More efforts are specifically needed to encourage women to pursue studies in science, technology, engineering and mathematics (STEM) disciplines to spur the availability of higher skilled labor (ibid. p.12).*

In general, a development up to higher skills is expected:

- *With regard to the introduction of more advanced products such as self-driving cars, smart clothing and IoT integrated consumer devices, production in E&E will be catalyzed., This will push the E&E sector to produce more innovative products, thereby leading to potential increased employment. However, assembling these more complex, higher-value products will require higher skill levels (ibid. p. 24/10).*

With a view to the competences required by enterprises, the findings of the studies can be summarized as follows:

- *Occupations in which the bulk of tasks are routine and follow explicit, codifiable procedures tend to be more adaptable to automation [...]. By contrast, jobs resistant to computerization involve extensive non-routine, abstract tasks that require judgment, problem-solving, intuition, persuasion and creativity [...]. Jobs that also resist automation are those with non-routine, manual tasks that demand a high degree of situational flexibility and human interaction [...] (cf. Chang/Huynh 2016, p. 18/6).*

The ILO draws the following conclusion from their studies:

- *Among the skills considered the most important, the most frequently cited was technical knowledge: named by almost 40 percent of respondents. Teamwork and communications skills were also viewed as highly important. Among the skills considered the most difficult to find, topmost were strategic thinking and problem-solving, followed closely by foreign language skills, technical knowledge, and soft skills such as creativity and innovation (cf. ILO 2016a, p. 36/6).*
- *Employers in ASEAN face shortages of hard skills and soft skills. Hard skills include English language proficiency, computer related skills and other technical skills; soft skills include time management, interpersonal communication, creative thinking, teamwork and leadership. Teamwork, decision making, independent communication and cooperation, among others, are increasingly in high demand in the manufacturing enterprises (cf. ILO 2016c, p. 36/18).*

The following competences are named as non-automatable:

- creative intelligence;
- social intelligence;
- perception and manipulation.

These competences are rated as bottlenecks for automation (cf. Chang/Huynh 2016). Some statements start at this point and demand more investment in higher education in order to support the tackling of complicated requirements, such as

- advanced levels of perception;
- manipulation, creative intelligence; and
- social intelligence (ibid. p. 32/20).

It is presumed that it will be necessary in the future to have a broad pool of competences and occupations available, notably

- technical skills;
- engineering skills;
- science and manufacturing skills.

It is expected that due to digitalization and other technologies such as additive technology, cloud compatibility, nanotechnology etc. the manufacturing sector will gain considerably more importance (ibid., p. 29/15).

The studies produced by ILO (2016), McKinsey and by Schwab (2016) predict a world-wide displacement of lower-skilled workers and an increase in the demand for higher-skilled personnel, above all technicians and engineers. As a consequence, very elaborate requalification processes must be initiated in order to maintain the employability of the workforce.

The ASEAN countries consider themselves especially affected by this development and presume that at least 60 percent of the workplaces are at risk – workplaces for women are more affected than workplaces for men.

However, the studies do not provide any detailed information on the way TVET could contribute to restructuring processes in the individual countries.

2.4 Conclusions

The evaluation of the studies on digitalization and the world-wide developments as well the developments in the ASEAN region revealed six irreversible trends:

- Digital technology is unstoppable and will be swiftly disseminated in all regions of the world.
- As an instrument of automation, digitalization will lead to a massive loss of workplaces. The concrete extent depends on the specific situation of the country and the sectors.
- However, new workplaces will be created and the workforce must be re-trained accordingly.
- Caused by the merger of different work-processes due to technological development, a hybridization of qualifications will occur. This means that broad competences have to be developed.
- It is imperative for the current workforce to be open to upgrading their skills and capabilities. This means that TVET institutions and governments have to ensure a quality-based training which fulfills the requirements of the changing workplaces.
- The changes of technology and work require well-qualified managers and engineers as well as highly qualified skilled workers who are able to interact with colleagues, to trouble-shoot, solve problems, analyze data and communicate effectively with all relevant persons and bodies.

All considered studies have a common starting point: Structural changes in the world of work which, in all countries, lead to the following developments taking place in enterprises, private and public bodies, and other institutions:

- technological and organizational changes;
- change of the contents and the structure of required knowledge and skills;
- change of the contents and structure of competences, qualifications and curricula;
- change of the structure and contents of the processes of education, training and assessment of learning.

These developments represent a massive process of change, with an impact on all areas of life.

The three scenarios given below summarize the simultaneous impact of state-of-the-art digitalization (cf. Hirsch-Kreinsen/Ittermann/Niehaus 2018):

- *Upgrading of work and qualifications* - Industry 4.0 will develop as moderate technological change in industry, followed by the corresponding upgrading and improvement of productivity and quality of work.
- *Automated factory* stresses differentiation of the loss of routine and low-skilled jobs in various sectors of the economy.
- *Work polarization* looks into the macro-structure of the labor market, claiming that in the development of Industry 4.0, especially the interplay between work automation and informatization, digital Taylorism tends to reduce the importance and need for middle level occupations and qualifications.

This process of change requires quality-oriented answers given by national and sectoral TVET systems. The challenge is to build up qualification structures which fulfill the demands of the outlined requirements. In order to reach this objective, policymakers must make innovative decisions in the short-term which have to be stabilized in the long-term. This means that it has to be quickly determined which occupational profiles need to be revised and which new occupations should be established and implemented.

In addition, the scope of engineering sciences which deal thoroughly with digitalization should be extended.

Changes of work and the new requirements for skilled work because of digitalization can be summarized on the basis of the analyzed studies and some surveys in companies (case studies in Germany) carried out under the lead of the authors (cf. Spöttl 2018):

1. Skilled workers, highly qualified skilled workers, technicians, i. e. persons with an occupational technical education and training and corresponding further training should be qualified for specializations relevant for Digitalization/Industry 4.0. They must be able to master processes in their complexity and to safeguard a flawless operation of plants.
2. The mastering of networked systems with decentralized intelligence, the ability to deal with data and their analysis as well as the ability to safeguard a flawless operation of the plants count among the most important requirements for work on production sites. Apart from this, it is of course expected that the existing traditional tasks for skilled work are still coped with.
3. The list of priorities represented by general questions of Digitalization/Industry 4.0 has to be extended by technological innovations, by issues of work organization, by questions of work design, data security, programming techniques, trouble shooting and problem solving with the aid of assistance systems and data analysis.

The software for technical networking and its related CPS elements are continuously disseminated. Along with the increasing diffusion of Digitalization/Industry 4.0, plants and machines must therefore be conceived and handled by starting with

- networking,
- CP-systems,
- the relevant software and
- their embedding into processes.

Thus, the interaction between man and machine is changing considerably. This is underlined by the more intense use of image processing, the transfer of information via visual processing in different user appliances, the use of videos and of audiovisual language etc. This requires broad competences which have so far not been considered relevant. The broad competences named in Chapter 4.5 count among the basics for being able to deal with “Digitalization/Industry 4.0”.

In other words: context related data have become dominant. They provide information on plants, production processes and process operations (see Chapter 4.5). With the aid of integrated sensors and actuators the behavior of machines is controlled, analyzed, and documented. The collected data are transformed into information for the plant operator, the workman and the skilled worker. The collected data form again the basis for tools which have to be used by skilled personnel according to the particular situation.

This raises the question of how Digitalization/Industry 4.0 will change the organizational processes and thus the hierarchies in companies. There are not many unambiguous research findings available in literature. Therefore, it still remains vague how certain decision making processes will change at the skilled-worker-level. Is there still space for co-shaping by human beings in Digitalization/Industry 4.0 or will Digitalization/Industry 4.0 promote a “Taylorism 4.0”? The developers and the drivers of the idea Digitalization/Industry 4.0 continue to stress that they are aiming at a cooperative interaction between all levels. Humans should be given the chance to exert influence on the shaping of their work within production. The working group Digitalization/Industry 4.0 comments:

“The Smart Factory contains opportunity structures for a new work culture which is oriented towards the interests of the persons employed. [...] Neither technology nor technical constraints should decide on the quality of work but scientists and managers who will shape and implement the Smart Factory. What is required in this context is a socio-technological shaping perspective within work organization, further training activities, as well as technology and software architectures with a close mutual coordination. They should be seamless and focus on enabling intelligent, cooperative and self-organized interaction between the persons employed and/or the technical operation systems along the entire value-added chain.” (Hartmann 2014)

The development of Industry 4.0 towards digitalization and its impact on the workforce has been surveyed in several studies and with different objectives. The results of the studies show that the current state of the implementation of Digitalization/Indus-

try 4.0 does not yet allow a reliable determination of the development of the need for skilled workers. However, all findings of the studies agree upon the fact that employment opportunities for low-qualified workers will decrease along with the implementation of Digitalization/Industry 4.0. A higher need of companies for trained skilled workers, highly skilled workers and academically qualified staff is predicted.

The digitalization of the world of work and living could be the result of the determination of the human being to shape his or her environment and of multifaceted negotiation processes. It is no deterministic technological process. Therefore, the following quotation should apply: "It is up to us to get used to a different paradigm and focus on upgrading our skills and maintaining our versatility and adaptability" (Owens 2015, p. 35).

3 Development of an Innovative Concept of Learning and Teaching

3.1 The foundation of the concept

With support from the RECOTVET programme, the TVET teachers training institutions in ASEAN have identified five state-of-the-art in-service training modules that are high on the agenda for all AMS in the era of industrial change. The training modules have been designed to support TVET staff through innovative teaching and learning, quality assurance and quality development in TVET as well as to maximize the competence of TVET teachers and managers of TVET institutions to keep up with the changing world of industry.

The development process of five modules⁶ for in-service training of teachers and trainers of South-East Asian countries started in June 2018 with an opening workshop. This was followed by a series of workshops with regional and national TVET training institutions and their “Community of Practice” commissioned to develop the training modules. The RECOTVET programme with its team of regional and international experts has supported the development of the training concept, manual and materials for the five regional training modules to train TVET staff in the region. The training materials have been uploaded to the regional sharing knowledge platform SEA-VET.NET and the online materials will be made accessible for the region.

Regarding the foundation of the concept, the most important step was:

- The design of an initial concept for training modules, and
- identification of the needs.

The explanation given in Chapter 2 formed the background for discussion of the needs due to digitalization. In addition to this information, the knowledge of the experts of the practical requirements in the field of work complemented the identification of the needs.

In order to create an initial concept of training modules, experts from training institutions were invited at an early stage to discuss possible concepts and the opportunities to implement them in training institutions.

Three main steps are required for developing and implementing the training modules:

1. Identification of the required modules – this identifies and designs processes to develop a clear and concise plan to best benefit the TVET community and is high on the list of demands for the TVET teachers’ trainings.

6 In this paper three modules will be presented in detail. These modules deal with Industry 4.0

2. Development of training modules – the second step is to best present “up-to-date” training modules to TVET teachers. By working with international and regional experts, institutions, and partners, the reviewed modules will bring participants and the TVET community together to jointly develop these.
3. Supporting TVET training at national TVET teacher institutions – actively working with national institutions is the best means to maximize training quality.

Three regional training modules “Fit for Industry 4.0” were approved by the 30th Governing Board Meeting of SEAMEO VOCTECH in Brunei Darussalam in September 2019 to be integrated and offered in the regional training programme.

In autumn 2019, RECOTVET facilitated the first batch of five trainings of multipliers. These were held in close collaboration with SEAMEO VOCTECH and partner institutions. As a result, more than 200 multipliers from 11 countries are now qualified to transfer their knowledge at the national level. By January 2020 the first batch of multipliers had already multiplied the training contents for almost 600 TVET teachers in 6 countries.

Thailand and Vietnam will have incorporated the in-service training modules in their TVET system as well as provided training on the developed modules effectively at the national level.

In October 2020, due to the COVID-19 outbreak, the in-service training modules were conducted online in 40 hours over 5 days per module, utilizing conferencing tools and a mostly synchronous, instructor-led learning format in an ad-hoc manner.

Multipliers are candidates from training institutions who possess relevant expertise and whose skills and qualifications match prerequisites for prior training. At the end of the training, multipliers will learn particular topics and skills, the importance of a well-organized training plan and the steps involved in creating an in-service training plan in their own institutions.

3.2 Overview of the training concept

This sub-chapter will create a training concept based on the ongoing changes due to digitalization and will help to build a deeper understanding of the impact of skilled work. The impact on and possible consequences for the industrial changes because of Industry 4.0 for TVET systems, TVET management and TVET training will be the main focus of this sub-chapter.

As a first step after the development of the concept, multipliers will be trained in further disseminating the developed training concept. The rationale and background for the training of multipliers including the introduction to the five training modules will be part of this sub-chapter. An introduction is given here and an explanation of Learn- and Work Assignments (LWA) is provided in a later chapter.

The main objectives of training of multipliers are to enable participants to:

- analyze the technological changes in teaching and learning and to initiate the necessary innovative teaching and learning for industrial changes,

- build the capacity of multipliers with regional training modules, concept of learn- and work assignments (LWAs), self-reliant learning, curricula and the training materials developed,
- acquire knowledge and skills on innovative technical developments as required by Industry 4.0 and digitalization,
- better design, plan, organize and deliver their own in-service training based on the training modules in the country,
- be able to use innovative teaching approaches to address self-reliant learning, problem solving, enhancement of communication,
- be able to make use of digital media to support learning and teaching.

Learn- and work assignments are core elements of the didactic approach dealing with different requirements of TVET. They contain aspects of all work-related subjects, subject matter elements, quality assurance requirements and express their interdependence. Learn- and Work Assignments are assignments for the students designed by their teachers, lecturers, instructors and trainers. It is necessary to design learning events, which provide the students with the opportunity to find appropriate solutions for the problems they encounter. Learn- and Work Assignments also offer a wide variety of learning modes which make them a flexible didactical issue⁷.

The Sustainable Development Goals (SDGs) indicate the importance of quality assurance in TVET provision. Accordingly, by 2030, access for all men and women to quality TVET should be ensured. By its very nature, TVET is designed to prepare a quality labor force to supply competent workers for the labor market and to prepare people for their role in society. Given this role, good quality TVET will significantly contribute to the economic growth and stability of a country. For this reason, working on Quality Assurance (QA) and Quality Development (QD) in TVET is imperative. This is the overall target of the training of multipliers.

In many instances, however, the reality is that many TVET centers are not yet able to demonstrate Quality Assurance of their training delivery despite various QA models that they embrace. In this context, QA work is often only understood as an instant measure to be implemented within a certain period of time and aimed at fulfilling some predetermined requirements of quality or regular accreditation. Modern technology and quality are not yet perceived as a continuous process nor so internalized that in the end they are practiced as a matter of course. Quality has to be developed. A lack of adequate technical equipment and quality instruments and poor training on quality are among the factors that lead to this situation.

In conjunction with the development of regional training concepts in the RECOT-VET programme the initiative was taken to develop teaching material in five fields in a second step:

- Innovative Teaching and Learning for Industrial Changes due to Industry 4.0,
- Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0,

7 In the case under discussion, the LWA will be used for the training of multipliers.

- Curriculum Design for Industry 4.0 work-process,
- Quality Assurance and Quality Development in TVET Institutions,
- Industry and TVET Institutions Linkages.

The material offers a collection of instruments that equips all teaching staff in TVET centers to manage and conduct their training works more effectively and efficiently.

3.3 Module structure of five modules

Based on the above-described idea to cover five contents areas within a further training concept for teachers, an adequate module structure was developed. During the development process it was necessary to clarify which requirements are dominant in the different countries and which module design would allow for the respect of the different interests and TVET structures of the participating countries. The result was a module structure which is shown in Figure 6

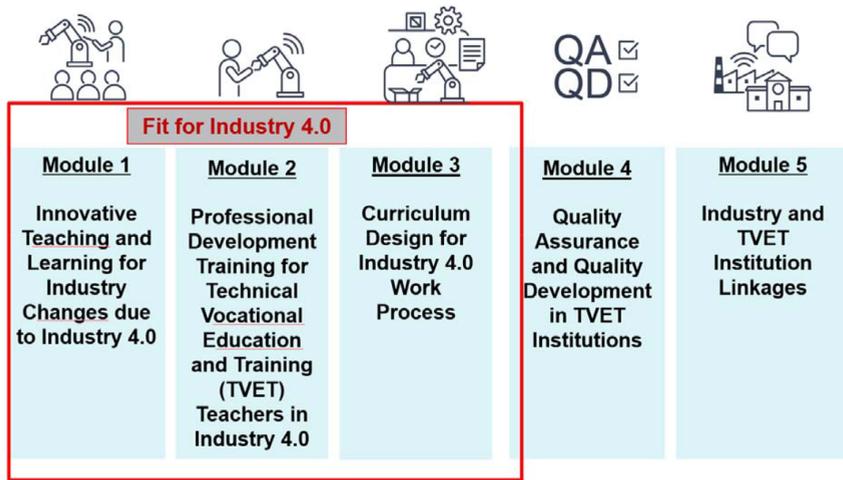


Figure 6: Regional in-service training modules for ASEAN Region

Module 1 to 3 are designed to improve management and teaching skills as well as technical and specialized skills of teaching staff. Modules 4 and 5 support the Quality Development in teaching processes and the cooperation with industry.

Modules 1 and 2 have to be organized in a chain and follow the main target of learning about the impact of digital technology and how it functions in the context of work. Laboratory training plays an important role in this process. Module 3 concentrates on the approach of work-process-based curriculum development with a focus on Industry 4.0. Finally, Modules 4 and 5 are dealing with quality issues and the cooperation between TVET institutions and industry.

As a special feature, “innovative teaching and learning” plays a central role in all modules. In order to facilitate this speciality, the didactic concept of “self-reliant learning” is adhered to in connection with the work on projects. More details will be given later in this document.

3.4 Definition of training modules for TVET professionals

The development of Industry 4.0 requires the enhancement of qualified work and the profiling of occupations which could contribute to the stabilization and further development of the TVET systems. Risks arise due to a devaluation of occupational tasks caused by automation which could render individual occupations and tasks superfluous. In order to support the further development of vocational education and competence development, an In-Service training concept “Fit for Industry 4.0 via Innovative Teaching” will be presented. At the core of the concept are five modules which cover 300 training hours.

3.4.1 Module 1: Innovative teaching and learning for industry changes due to Industry 4.0

The 4th Industrial Revolution (Industry 4.0) has affected every aspect of the world of work. In the literature, the term “disruption” is widely used to represent these changes. The impact of Industry 4.0 is manifold. All the working areas in a smart factory are confronted by new working opportunities offered by using Cyber Physical Systems and the changes in work-processes and work organization. Dealing with a number of different data formats, high quantities of data, cloud computing, data safety and data mining are new dimensions of work on the shop floor with which everybody is confronted.

This module will introduce the changes going on based on lean production and will build a deeper understanding of the impact on skilled work, thus creating awareness of the workforce required for Industry 4.0. It will also introduce the use of different data, the different safety systems and the use of IT safety systems to make work safer.

The impact and possible consequences of the industrial changes because of Industry 4.0 for TVET and TVET management will be the main focus of this training programme. Awareness of the impact of the technological changes on teaching and learning will also be prepared and discussion on innovative teaching and learning for industrial changes will be initiated and integrated into the whole number of training deliveries.

Major topics that will be covered during the course (including 3 to 4 days laboratory and 2 days of company visits, duration 2 weeks):

- terms, introduction to industrial change, change of work, new technology and knowledge,
- impact of Industry 4.0 on changes to the digital work environment at the shop-floor level,

- wider usage of Internet in the work-processes of mechatronics systems and other relevant areas, e. g. agriculture and services industry,
- data availability of sensors, actuators and process data in production systems: Production Planning System (PPS), Manufacturing Execution System (MES), Supervisory Control and Data Acquisition (SCADA), Enterprise Resource Planning (ERP), SAP - System Applications, Products in Data Processing,
- data handling: saving data, cloud computing, data security, data mining,
- structure of technical networks and transfer of big data,
- the smaller series and individualized production, executing frequent diverter/ adjustment works and operations,
- process management (visualization/ monitoring/ coordination/ organization),
- operation and monitoring of Cyber Physical Systems (CPS),
- operation and control of automatized and robotized work-processes of assembly,
- guarantee process safety by process monitoring and repair of malfunctions,
- innovative didactical approaches to learn and teach within Industry 4.0,
- didactically implementing the topic into the vocational training courses,
- usage of soft skills in learning and teaching courses related to Industry 4.0,
- design of typical learning scenarios,
- development of innovative lesson plans related to Industry 4.0,
- assessment of students' performance in the era of a digitalized world.

3.4.2 Module 2: Professional development training for TVET teachers on Industry 4.0

The capacity of TVET teachers to successfully manage and implement the overall working processes needs to be continually improved. Today, the 4th Industrial Revolution (Industry 4.0) is initiating changes all over different business sectors and in private life. In the literature the term “disruption” is widely used for the changes. All the working areas in a smart factory have to deal with the new working opportunities offered by the use of Cyber Physical Systems and the changes in work-processes and work organization. This module focuses on the continuous professional development of the TVET teachers' capabilities that play a pivotal role in:

- updating knowledge and pedagogical skills (based on different and new technologies, change of work, know-how, materials etc.),
- upgrading specific technical competences,
- upgrading teaching skills in the context of complex technology and the work-process relation,
- enhancing industrial experience.

Industry 4.0 is integrating a variety of different technologies into a complete system. The most important features of this system are the intelligence of the individual components and the way that these components network with smart factories. This will be the main requirement for a teaching process and methods are needed for the best way to teach it.

Major topics that will be covered during the course (most of the training takes place in laboratories, duration 1.5 weeks):

- interface of 3.0 & 4.0 and their differences and reasons for the need of 4.0,
- impact of Industry 4.0 in changes of work on the shop floor level,
- wider usage of Internet in the production and business processes of industry production,
- new level of technical and software-based communication between the Cyber Physical Systems and the Internet or Internet of Things,
 - the importance of software,
 - the digital communication between different systems,
 - digital-based communication process between the different instruments and machinery and malfunctions,
 - introduction to Enterprise Resource Planning (ERP),
- process management (visualization/ monitoring/ coordination/ organization),
- efficiency: usage monitoring, recording consumption, localizing and identifying energy losses, drawing conclusions from increased energy consumption about component wear and behavior in the event of failure,
- design structure of Industry 4.0 factories: sensors/actuators, process modules, cells, networking, process and operation command level, MES,
- RFID and NFC to identify products that need to be manufactured,
- “Manufacturing Execution Systems (MES) simulation”: creating, managing, controlling, and visualizing orders on the value-adding process level,
- customization and individualization of the products,
- new approaches to the planning and organization of TVET training,
- preparing training and education with the help of projects or self-reliant learning in the context of Industry 4.0 topics,
- didactical approaches to learn and teach within Industry 4.0.

3.4.3 Module 3: Curriculum design for Industry 4.0 work-process

This module is designed for the development of work-process oriented curricula fit for Industry 4.0, in particular focusing on the labor market demands. In this context, it is important to include the social implications of work in relation to each specific cultural context in order to ensure sustainability. It will also be introduced into a learning and teaching model (e. g. self-reliant learning) to demonstrate the implementation of work-process-based standards.

This course/module will develop the participants’ abilities to carry through work-process analyses for curriculum development and apply the self-reliant learning model in developing competences that will respond to labor market needs. The training takes place in seminar rooms combined with some company visits. Duration 1.5 weeks:

Major topics that will be covered during this course include:

- curriculum design in the context of Industry 4.0:
 - overview of Industry 4.0,
 - curricula as the backbone of quality TVET,

- labor market:
 - current demand,
 - skills anticipation,
 - 21st century skills
 - competences required for Industry 4.0,
- approaches for curriculum design and development,
- work-process-based curriculum:
 - state-of-the-art curriculum (work-process-based curriculum),
 - curriculum design suited to Industry 4.0,
- guidelines for development of advanced detailed curriculum:
 - work-process analyses,
 - development of draft advanced occupational standards,
 - development of advanced detailed curricula,
 - steps for the development of advanced detailed curricula,
 - dimensions of curricula,
- application of self-reliant learning approach,
- curriculum evaluation.

3.4.4 Module 4: Quality Assurance and Quality Development in TVET institutions

Sub-Module 4.1: Quality Assurance in TVET institutions

This module is designed to facilitate TVET managers and TVET quality managers in introducing and setting up a quality assurance system in their respective institutions.

Different Quality Models (QM) will be introduced, taking into account the models used in other countries. Examples are the European Framework for Quality Management (EFQM), assuring the quality of organization day-to-day operations and continuous quality improvement, ISO 9000 series of standards on Quality Management System, Quality through Development and Evaluation (Q2E), Quality Information System (QIS), evaluation in a team.

In this module, the QA cycle (PDCA = Plan, Do, Check, Act) and QA system approach (Input-Process-Output) will form the core of all the discussions.

Participants will acquire competences for applying significant quality management tools and learn to establish a QM system in their vicinity which considers the quality of the educational process and the quality of the school as an institution and organization. Various approaches towards excellence will be discussed and concepts for implementation of one or another model will be analyzed.

The cooperation with different stakeholders and ways to “measure” achieved results will be presented. The RADAR (Results, Approach, Deployment, Assessment and Review) assessment framework will be introduced. The training takes place in seminar rooms. Duration of sub-modules 4.1 and 4.2 are 1,5 weeks:

Major topics that will be covered during the course:

- quality management approaches,
- quality assurance approaches from ASEAN, Europe as well as frameworks,

- quality management model,
- the QA cycle (PDCA),
- Input-Process-Output dimensions of QA,
- QA & QD as a continuous process,
- the RADAR assessment framework,
- instruments/methods for effective learning,
- role of stakeholders.

3.4.5 Module 4: Quality Assurance and Quality Development in TVET institutions

Sub-Module 4.2: Teacher & Manager as Supporter of QA & QD in TVET

The target of the module is to enhance the capacity of TVET teachers and managers of quality management systems at the operational level. Through exposure to various Quality Assurance approaches which are relevant for the daily work, the module should enable TVET practitioners to plan, design, implement and evaluate quality assurance measures particularly in learning and teaching processes and in an integrated and continuous way. In this context, Quality Assurance and Quality Development are embedded in the training institution.

The use and performance of modern teaching methods will be addressed in order to manage quality in TVET -both in the institution and in classrooms, thus supporting cooperation with industry, strengthening the role of teachers in QA and QD and installing a quality culture in teaching and learning in TVET institutions. Within this context, different QA instruments will be introduced and partly simulated in a participatory and activating mode.

At the end, the module should equip the participants with a set of competences that allow them to optimize existing QA practices within their institutions, to introduce new practical approaches and/or to design and manage new QA and QD processes.

Major topics that will be covered during the course:

- development of a quality culture,
- role of teachers in QA and QD,
- teamwork to support QD & QA,
- teaching methods for better learning,
- vocational pedagogy for efficient learning,
- cooperation with industry for supporting quality in training.

3.4.6 Module 5: Industry and TVET institutions linkages

The in-service training module on Partnering with Industry: Industry and TVET Institutions Linkages (Module V) should support and empower management and teaching staff of TVET institutions in order to improve demand orientation, effectiveness and efficiency in designing and implementing TVET programmes by focusing on the establishment/ improvement of the cooperation between TVET institutions and industry. Based on best practice examples, participants will evaluate and identify approaches for adaptation and will develop/adapt the training concepts according to the existing

needs and situations in their individual national contexts. The development and dissemination of the module involves national multipliers for further dissemination and development. SEAMEO VOTTECH will be involved at a regional level in Southeast Asia.

Major topics that will be covered during the course (the training takes place in seminar rooms combined with some company visits, duration 1.5 weeks):

- characteristics and advantages of cooperation between TVET institutions and industry (arguments for involving business sector in TVET, stakeholder groups and interests),
- national law, framework and policy contexts for encouraging cooperation between TVET Institutions and industry,
- core elements of cooperation between TVET institutions and the business sector (occupational standards, curricula, training programmes, assessment, testing and certification, exercises and self-development),
- examples/ cases for the joint development of occupational standards, curricula and training programmes (motivating companies, from Training Need Analysis (TNA) to training, exercises and self-development, sample case),
- organizational development in TVET schools towards feasible cooperation mechanisms between TVET institutions and industry (examples for setup, communication strategies, installation of boards, examination and testing committees),
- cooperation between the TVET personnel (identification of roles of instructors and teachers, managers, coordinators, etc. within cooperation models),
- experience of piloting cooperative models in TVET education and training,
- tracer studies and enterprise surveys as instruments for evaluation of success (e. g. example from Vietnam and other countries),
- analysis of cost positions and opportunities for cost sharing between TVET institutions and private sector (costs and benefits, cooperation impact and cost sharing).

The detailed concept of the modules – including outcomes, expected competences, didactical concept, learning environment – is explained in Chapter 6. Nevertheless, modules 1 to 3 are only dealt with separately as they mainly concentrate on the challenges of Industry 4.0. Modules 4 and 5 deal with general priorities (quality and cooperation of learning environments) important beyond Industry 4.0.

4 Didactical Concept and Transfer into Learning Processes

4.1 Introduction

The term “learning culture” is frequently used in order to develop new ideas for learning and – based on this – to name a “programme” as orientation for certain societal groups. Learning is no longer seen as an organized process to transfer predetermined knowledge. Moreover, this perception is opposed by a concept that regards learning as

- a self-directed process,
- a process marked by one’s own initiative,
- a holistic process (principle of brain, heart, and hand) and
- a self-related process.

These terms alone, however, do not describe anything dramatically new for vocational learning. They are also used to characterize a mode of instruction in vocational centers that is task based orientated. A reorientation of the teachers (to-be) in vocational education and training seems to make sense and is legitimate in the light of their role as important co-shapers of vocational learning. Nevertheless, this is not enough. What is important beyond “adaptation” is a perception which considers the shaping of the learning process and the work environment of teachers and students. Thus the shaping of instruction and the learning processes, as well as the further development and the shaping of school structures become domains of a learning culture of the teaching staff and students.

With the perception of a new learning culture in mind, we can easily conclude that the established ideas of learning comprise a certain focus on self-reliant learning. However, the learning culture should be determined by student-centered learning. This reorientation of learning is to be understood as a paradigm shift for the perception of learning as such. Currently this change is justified by the dominating concept of institutionalized learning which is deemed to be little effective and which is at the same time based on the assumption that externally organized impulses are necessary to initiate and control the learning processes.

However, the question is if and to what extent, the externally organized impulses can be abandoned in order to give space for the positive aspects of self-reliant learning. A related basic assumption is:

that students can learn in a self-organized way regardless of their preparatory training or age and that learning is a central value governing the behavior of the unity and the subject.

Such a perception of learning postulates that the influence of an individual's learning on the changes in the institution ("the unity") is recognized and volitional as this eventually leads to a certain pedagogization of the world of work.

4.2 Framework of the didactical concept

Due to manifold developments in the world of work and industry, Technical Vocational Education and Training (TVET) will be geared towards the production of a "multi-skilled knowledge workforce", versatile, willing to learn continuously (Life Long Learning – LLL) and able to acquire, apply and create knowledge, capabilities and skills, particularly in modern technologies or – better – in digitalization. Instead of multi-skilled knowledge, other terms are frequently used as there are 21st century skills, broad competences and others.

An overall requirement to deal with the manifold developments within education and training is the "competence to act". This competence combines four sub-dimensions which are at the center of education and training:

Competence to act

Competence to act is the central task of vocational colleges. It is the willingness and ability of an individual to act properly as well as individually and socially responsibly in societal, occupational and private situations. Competence to act unfolds in the dimensions of professional competence, personal competence and social competence.

Furthermore Hoepfner/Koch (no year) state:

"Professional competence is the willingness and the ability to solve tasks and problems in a target oriented, proper, methodological and autonomous way based on specialist knowledge and methods and to assess the results."

"Personal competence denotes the willingness and ability of individual personalities to clarify and assess the development options, requirements and restrictions within the family, the profession and the public life, to unfold one's own talents as well as to envisage and further develop life plans. It encompasses personal properties such as autonomy, ability to criticize, self-reliance, reliability, responsibility and conscientiousness. Personal competence also includes the development of reflected moral concepts and a self-determined adherence to values."

"Social competence is the willingness and the ability to live in and shape social relationships, to perceive and understand sympathies and tensions as well as to deal with and handle others in a rational and responsible way. The development of social responsibility and solidarity belong to this competence."

Further elements of social competences are: communicability, tolerance, partnership, proper forms of communication with people, social activities, entrepreneurial skills, team working, management of transaction relations and leadership.

Competence to act is the ability to generate a basically indefinite variety of situation-adequate actions from a limited system of elements and rules (knowledge basis).

Two of the central components of competence to act are:

- the ability to perceive situations and/or an orientation e. g. for the adequate inner modelling of acting situations.
- the ability for the transformation of situations, mentally during problem solving and/or in reality in the course of practical activities.

“Methodical competence is the ability and willingness to proceed in a target-oriented, planned way when handling professional tasks and problems. Learned ways of thinking and work-processes are independently chosen, applied and in some cases also further developed.” (ibid.)

To develop these competences within education and training efforts requires innovative training methods which will be discussed below. Didactics thus deals with very comprehensive main points. The following issues need to be clarified:

- Which competences can be developed with which teaching and learning methods?
- What should be the contents of training?
- Which role should the manifold factors of influence play during learning and how can they be taken into account during the planning phase?

The first question will be defined in detail below with a focus on the approach of self-reliant learning.

The second question has already been answered within the framework of the development of module contents with groups of experts and the validation of the modules and the Learn- and Work Assignments. During several meetings with experts, the questions regarding contents were clarified. With the aid of Learn- and Work Assignments, curricular basics were created which allow promoting and moderating a process of self-reliant learning. Based on the Learn- and Work Assignments, it is at the same time possible to establish a link between learning and working.

Figure 7 provides an overview of factors exerting influence on learning processes. During the planning phase it must be decided which weighting should be given to the individual factors during learning. These considerations are strongly influenced by the favored learning theories and exert a significant impact on the results of learning.

This short introduction already shows the complexity of the shaping of learning processes and which factors have to be taken into consideration. Chapter 4.4 and 4.8 characterizes selected learning theories. Each of these theories leads to a different setting of priorities in the choice of influence factors. The approach of self-reliant learning is favored for the selected target group as this approach corresponds very well with the target of the development of competences to act.

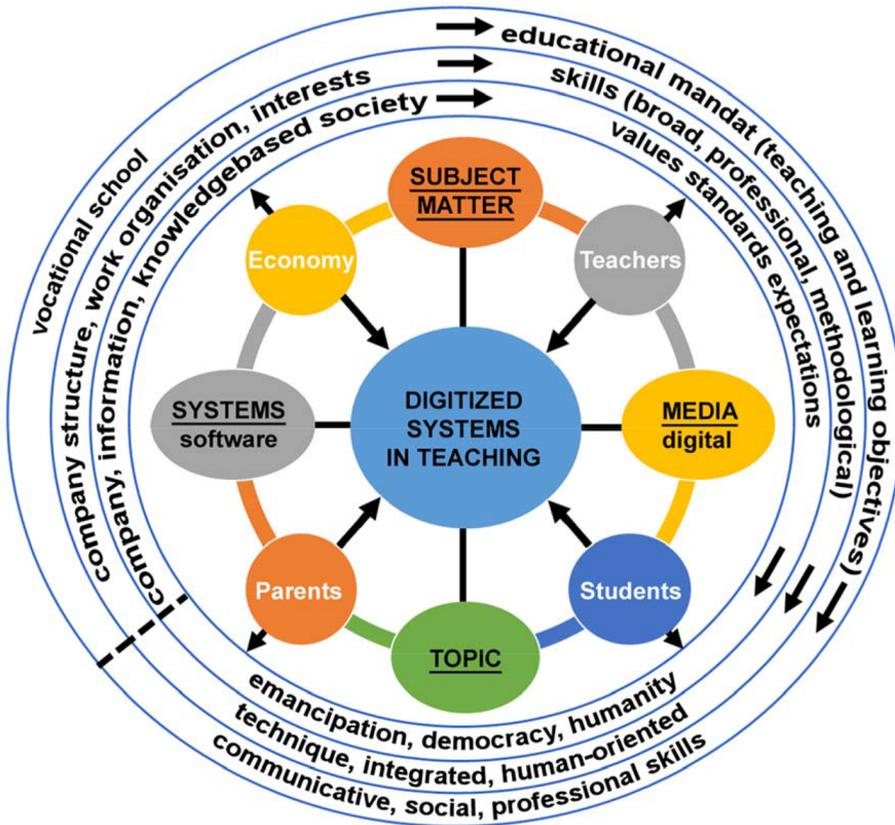


Figure 7: Didactical framework related to digitalization (Source: Spoettl)

4.3 The target group

The overall target group for the programme of further training and education is the so-called TVET personnel, including:

- teachers of general or TVET-specific subjects within vocational education;
- teachers, trainers and instructors of theoretical or practical subjects in vocational institutions;
- Instructors of laboratories (technical labs, labs for digitalization, FabLabs etc.) within vocational institutions;
- coordinators of training programmes;
- management staff as far as involved in the operation of training programmes;
- representatives of TVET government units.

It would be an advantage for the participants to have some industry background and one to two years' experience in vocational institutions.

The reason for choosing this non-arbitrary target group is the fact that all further training priorities – with the exception of digitalization - are highly relevant for them, for example:

- quality assurance and development;
- digitalization and innovative teaching, and
- curriculum development.

Without preliminary knowledge of and experience with these issues, the benefit from further training would be at stake.

Involving management personnel and government representatives is because the implementation of new approaches always needs political support and modifications of the infrastructure. The participation of these groups on the control level could generate sensitivity for the need of further development.

4.4 Self-reliant learning⁸

Self-reliant learning is a pragmatic vocational theoretical approach which can be integrated in different issues of education and vocational education. The core of this approach is that it supports the active development of competences of all persons involved. In particular it supports the ability to become a self-reliant learner. This plays an important role in using work-processes for learning and during one's continuing professional development.

The demand for self-reliant learning in general is uncontested in the pedagogical world and is becoming more and more valid for the technical training. The ability to be a self-reliant learner plays an important role in the shaping of work-processes and continuing professional development in countries. The importance of the ability to be a self-reliant learner in technical training plays an equally important role in the development of competences. Concrete requirements for fostering self-reliant learning abilities are a universal requirement nowadays. An important requirement is to produce a multi-skilled knowledge workforce that is versatile, willing to learn continuously and that can acquire, apply and create knowledge particularly in modern technologies. The way to impart these abilities is a designated trainee-centered teaching approach, supported by self-reliant learning.

This description is to show and to explain to teachers and instructors how they can implement trainee-centered teaching in TVET. It is designed to put the teachers and instructors in a position to understand their students' learning processes and to understand their learning and work activities in detail in order to plan and deliver an appropriate teaching process.

⁸ The material is a modified and shorter version of the concept which was developed within the GIZ Dual System Project in Malaysia by Hans-Dieter Hoepfner and Hermann Koch. The authors were also supported by Gert Loose (head of the GIZ Dual System Project) and Georg Spöttl.

The topics that are explained in the text are:

- the nature of learning and action and their association,
- the connection between learning and working,
- tools for better understanding self-reliant practical exercises and work activities,
- tools for designing practical exercises and work assignments for self-reliant learning,
- guidelines and hints on how to promote and moderate self-reliant learning.

4.4.1 Justification of self-reliant learning

Self-reliant learning is a natural way of learning!

Wherever experts these days talk about learning processes, you will hear the term “self-reliant learning”. It seems to be a very successful new way of learning to cope with all the problems occurring nowadays – problems with the rapid increase of knowledge, rapid change of technology, loss of stable employment and uncertainty in all areas of society.

Self-reliant learning can appear in different forms. It can be just learning by heart (in order to acquire rules or formulas, vocabulary etc.) or learning by solving more or less complex practical or theoretical problems. Learners are very active, they perform actions and they take over responsibility for their actions.

The opposite of self-reliant learning is reliant learning. People who learn reliantly are reliant on knowledge portions given by a teacher, on demonstrations done by a teacher, on the supervision of their activities by a teacher and on assessments of their learning results done by a teacher. They do not ask a lot, they watch, they listen and they imitate what their teacher does.

In reliant learning the students have to follow, have to listen and to watch. There is someone in front of the class speaking about and explaining something that is – as he/she thinks – interesting for the students. At school, our whole world is broken down into different subjects. A teacher conveys his/her knowledge about “his/her” subject to the students and he/she often does not refer to the subjects of the other teachers. Teachers live in their single subject world and teachers of other subjects are aliens. It is very difficult for most of the students to build an association between the contents they have learnt in the framework of different subjects.

At training centers, the learning is more practice related but instructors tend to break down the whole working world of an occupation into a lot of different subjects. Traditional training tends to target the conveyance of firmly defined skills. The traditional instructor “owns” the knowledge and conveys it to the students. He/she is bringing the content and the answers to problems into the training room with him/her.

Our younger generation is used to getting information that they need and not only from their parents, teachers and instructors. They also ask their friends in their peer group and they increasingly “ask” electronic media, as they are quite capable of dealing with these – often much more than adults – their teacher included. This situation is combined with an enormous growth of their self-consciousness resulting in much more independent action.

4.4.2 Strong association between human action and learning

The pedagogical demand for self-reliant learning has a long tradition. In Europe it goes back at least to the 17th century to the famous educator *Comenius*. His book “*Magna didactica*” contains many statements like the following: “With forging you can become a black-smith”. He wrote about the importance of doing within the teaching and learning process. Learning by doing was his motto.

Psychologists have discovered that learning and doing, particularly the actions of human beings, form an integrated totality. Human action has been the focus of their research work over the last fifty years, and they developed the so-called “Action regulation theory” in the 1980s. Action regulation theory is a psychological theory of human actions, concerned with modeling the ways in which people set goals in their mind, break them down into sub-goals and create a rough plan in their mind before starting to bring it to fruition through coherent action steps. In other words, the relationship between thinking and doing is at the center of this theory. This means that any practical action begins in the mind. Correct action means correct thinking first. In this context, acting means that for an activity a goal has to be set. Activities without a goal are not called actions. *Figure 8* shows the connection between action, action structure and action competence and explains the correlation between acting and learning. The bases of action orientation evolved from two tendencies of psychology. A very strict examination of the existing concepts shows that it would be appropriate to differentiate between an “acting” and an “action” training. The “acting” training refers significantly to the activity theory of the (Soviet) materialistic psychology (representatives: among others Galperin, Leontjew, Wygotski). “Action” training mainly concentrates on the cognitive action theory (representatives: among others Piaget, Aebli). Thereby the materialistic psychology strongly emphasizes the role of activity in forming psychological phenomena. It is remarkable for this process of reflection that the outcome is no static figure of the objects of insight, but that the original, sensual content of an object changes itself within the process of insight.

Neuroscientists have gained a lot of attention in the last fifteen years in Germany, and a model named “neuro-didactics” (Hermann 2006) has been published. Neuro-didacticians claim to help the teacher to realize “brain-adequate learning”, whatever this means. Some of the research findings of neuroscientists are really interesting, and some of them have been well-known for centuries.

As shown in *Figure 8* human action starts with setting a goal and breaking it down into a sequence of sub-goals – designing an action structure or plan. This plan has a rough structure and there are different options for the sequence of sub-goals. The acting person applies the plan in mind – thinking in advance. He/she looks for helpful knowledge, guidelines, experience in action competence (“action - store” see *Figure 8*) and get information from external information sources. Then appropriate competences and information is used for making a decision: What could be the right plan?

Within the planning and decision-making phase, the person learns to gather information mentally and from external information sources. He/she learns which competences are useful for planning in a specific situation.

The plan is carried out in practice after the decision is made that the plan is appropriate. He/she follows the plan and compares the interim results with the planned sub-goals. Comparison results clarify whether or not it is necessary to change individual activity steps or the whole plan.

Within the execution phase, the person learns to monitor his/her activities and to memorize successful activity steps (skills) and appropriate knowledge, strengthening the volition to achieve the set goal.

At the end of the action process the person compares the results with the plan by a final assessment: Has everything been considered? What should I change next time? Should I extend my search for information? What kinds of knowledge and skills have been especially helpful?

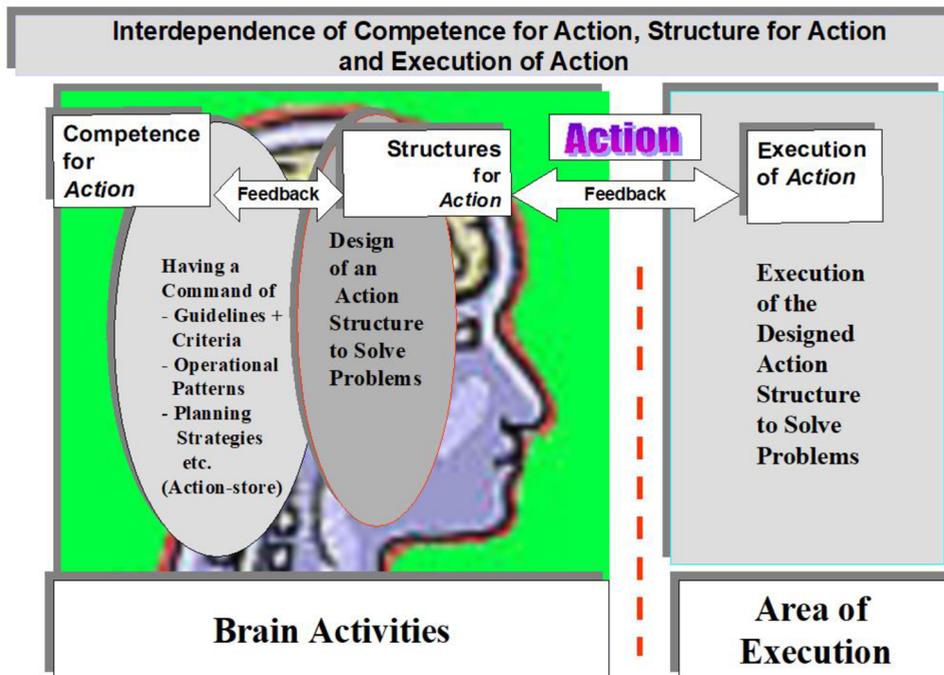


Figure 8: Interdependence of competence for action, structure for action and execution of action (Source: Hoepfner/Koch)

4.4.3 Action competence

Action competence means having a successful plan and the required knowledge for carrying out an action and storing it in one's mind.

The procedure explained above is called a “complete action”. A person learns self-reliance during this kind of action. Complete actions and their results establish action competence in our minds in an optimal way. Table 6 gives an overview of the components of action competence.

“Knowledge” and “ability” are other expressions for competence, the ability to learn, or “learning competence” and methodical competence as well as human and social competence. Action competence comprises more than these –volition and feelings are as important as the other components. In complete actions an active person learns to strengthen their volition, they become acquainted with acts of willpower. They are rewarded with positive feelings after successful activities and they learn to cope with negative feelings after failures (cf. *Figure 9*).

Table 6: Overview of components of an action competence (Source: Hoepfner/Koch/Spoettl⁹)

Knowledge	Volition
general knowledge	to achieve aims
special knowledge	to be responsible
guidelines (how to communicate; how to plan operation patterns (skills))	to act independently to use intuition
Ability	Feeling
carrying out operations	feel progress
carrying out planning processes (individually or in a team)	feel responsibility
applying knowledge ...	feel independent
	feel accepted

Figure 9: Summary – Pedagogical conclusions (Source: Hoepfner/Koch)

Pedagogical conclusions for combining learning and action

- A very important way to learn is to perform an action. Such learning is self-reliant learning in its optimal form.
- The actions chosen for your students’ learning processes have to be from a field of subjects in which the learners are interested in setting or motivated to set their own goals.
- Teaching has to support the processes of
 - setting goals (self-planning),
 - comparing planned and achieved results (independent decision making and self-monitoring),
 - final assessment/ evaluation with regard to the acting/learning results (self-evaluating, self-assessment) and
 - keeping oneself continuously informed.

9 The source is an unpublished slide selection.

- Teaching has to take into account that only complete actions have optimal learning results.
- Action is instigated by problems. The problems have different levels. At the first or lowest level they require seeking steps towards a given goal; at the second level they require finding and formulating a goal in a given framework of possibilities; at the third or highest level they require finding and formulating new – innovative – goals.
- There is no isolated action in our world. Actions have to be seen in a context. This has to be considered if you plan actions for self-reliant learning for a training course. You should start with problems/tasks which give an overview and an orientation of the course subject, then give problems/tasks for acquiring detailed, functional and specialized knowledge and skills.

4.4.4 Changes require a new kind of learning in TVET

Self-reliant learning as a natural way of learning is described in the first paragraphs of this chapter. Here it is explained that self-reliant learning is a demand of our present and future world of work.

Today's world is a world of change and uncertainty. Long-time values are changing or disappearing as are long-time societal systems and rules, and long-time ways of manufacturing and producing are changing. Skilled workers trained for a certain field lose their jobs and cannot find new ones in their field. They have to acquire new skills and knowledge for a new – and often completely different – working area.

In the past, occupations, companies as well as entire manufacturing/production fields existed for long periods of time. Today As a result of the globalization of trade and competition and the rapid change of technology, this is no longer the case today. Work-processes within the same company are changing completely and the remaining workforce has to adjust and to become acquainted with the new one.

The extremely rapid pace of technological change and the steadily increasing complexity at the work place (cf. Figure 10) have cut short the “longevity” of competences needed for the workforce to be in charge of work-processes.

In order to explain the effect of the process of change on the established knowledge in a particular field of technology, the concept of the “half-life” (or half-life period) of radiating material has been borrowed from nuclear physics. The half-life of radiating material states how much time will pass until half of the isotopes have lost their radiation. Correspondingly, the half-life of knowledge states how much time will pass until half of the knowledge that is needed to be in command of a particular area of technology has become outdated and therefore useless. While the knowledge with which our children graduate from school still has an estimated half-life of 20 years, this time for the field of computer technology is down to just one year. In other words: after one year 50% of the knowledge, which is needed today to be in command of computer technology, has become outdated.

The complexity of work situations in industry is increasing steep. What is the impact of this development on the design of training programmes? Traditional training concepts cannot cope with this new situation at the workplaces.

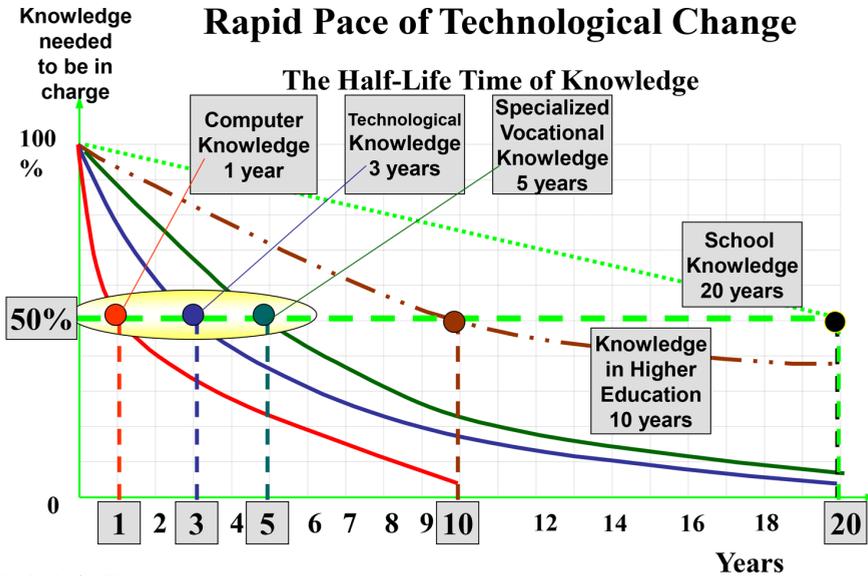


Figure 10: The extremely rapid pace of technological change (Source: Loose¹⁰)

In fact, workers/employees already holding jobs have to learn continuously in the same way as people who are applying for new jobs. They have to enlarge and enrich their knowledge and they have to acquire new knowledge (nowadays many are confronted with requirements out of digitalization) and they often have to do it without the help of a teacher – in many cases they are left to their own devices. That is the reason why we have to prepare all workers and employees – not just the younger generation – for the challenges of today’s industrial world, making sure that they are able and willing to learn continuously, that they are able to acquire competences independently, particularly at their work place, and learn together with their colleagues. It is one of our main duties to teach our students “how to learn”, to prepare them for the ongoing self-reliant learning processes of tomorrow.

Another justification has to do with the demands of state-of-the-art production and manufacturing. It is necessary that the leader in a national or an international market:

- is producing/manufacturing/assembling according to the demands of the customer as quickly as possible and deliver high-quality products;
- responds to all customer requirements,
- can offer a certain number of specific products,
- can offer a variety of versions in a large-scale production,

10 The source is an unpublished slide selection.

- can provide the customer with “just-in-time delivery” (SME have to deliver the demanded products to big companies just in time, e. g. when they need them in their manufacturing/assembling line),
- can achieve a zero-error production/manufacturing/assembling.

Large hierarchies in companies with several management and planning levels above the level of workers cannot accomplish the above-mentioned objectives. The information flow is too long and awkward and a lot of information gets lost along the way. The planning procedure takes too much time and therefore the special just-in-time demands of the customers cannot be met. Old-fashioned supervising has a negative impact as well. If all activities of workers are supervised workers start relying on the supervisor and not on their own judgment and abilities. If workers, who are used to being supervised, lose supervision for a certain time, they make a lot of mistakes and production quality is low. Apart from that, producing, manufacturing and assembling highly complex products cannot be supervised properly all the time and managers have to rely on self-monitoring and self-evaluation by their workforce. With the Industry 4.0 concept the paradigm of production and in other fields will change and the workforce will be confronted with different requirements they have to deal with in ways which are currently not very clearly defined.

It is expected that the hierarchy in big enterprises and SME has to become smaller and the workforce must be able to react flexibly to demands. The workers have to be able to take part in the planning process, in decisions related to the work-process and the applied technology, and the workers have to be able to monitor and evaluate their own work to ensure high quality products by themselves and by their teams. The ability of the workforce to work as a team, mutual monitoring and common responsibility are becoming more and more important. The workers have to become “Knowledge Workers” (cf. Figure 11).

The final justification has to do with the steadily increasing responsibility of workers within the production process as well as with humanity. The human being at the worker level can become a plaything of all the forces within the characterized process of change, with no opportunity for an active role when he/she can only react to the demands. As explained above, workers in highly developed industries are playing a different role in the company today than in the past. The modern worker is responsible for delivering high quality, better service and reasonable prices. He/she play an important role in the process-oriented work-organization – from the initial customer order and the planning process to the final quality control and the delivery of the product to the customer.

Today workers have more responsibility within this process. Their tasks comprise planning and monitoring responsibility and are also becoming more and more complex. Associated with their extended role within the companies, they have to take care that the work-process and the technology are designed in a manner that enables them to fulfill their new role. For this purpose, they need the competence to critically judge

and assess the work-process and the technology. Workers have to pose and to answer the questions:

- Why is technology structured like this and why is it used in this way at my work place?
- Why is work organized in precisely this way at my working place? and
- Could the job be done otherwise? Which alternatives are there?

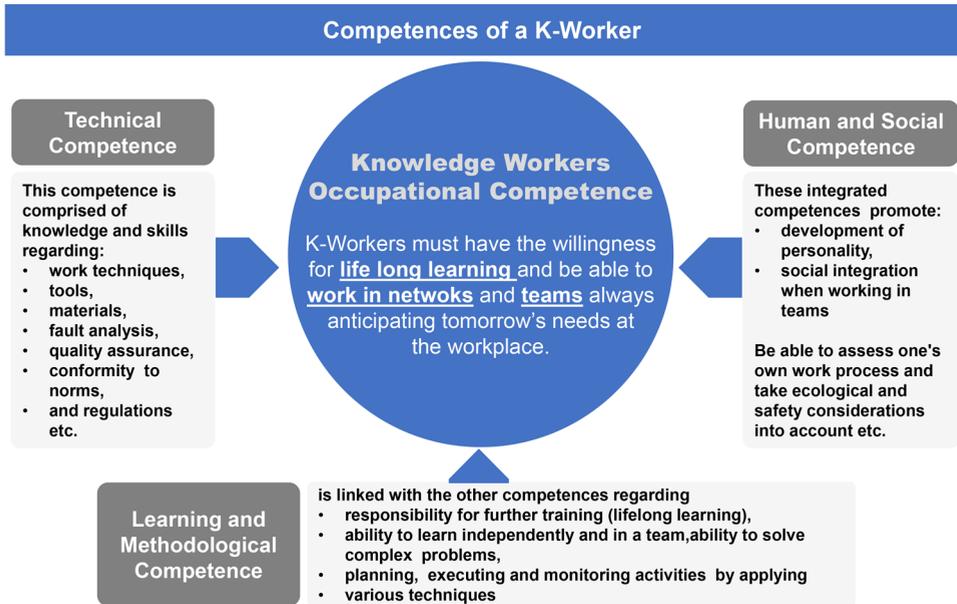


Figure 11: Competences of a knowledge-worker (K-Worker) (Source: Loose¹¹)

Establishing a culture of self-reliant learning in TVET is supposed to include this. Learners should be encouraged to seek answers to these questions within the framework of their learning and work-processes.

4.5 A new didactic approach for TVET

In the publication at hand, the term “didactics” is used in a much broader sense as it usually happens in English speaking countries. This broad view – as used in Central Europe – is very important for TVET. That is why it is explained at the beginning of this chapter. Table 7 is comprised of the components of the notion. Didactics is a science and this science is concerned with the:

¹¹ The Terms of Competence are different to the one mentioned in Chapter 2 although there are similarities. The term “Technical Competence” is narrower than the term “Professional Competence”. The source is an unpublished slide selection.

- subjects relevant for training and education,
- methods of teaching and learning and their mutual association,
- objectives of teaching and learning and their relationship,
- subjects being imparted and acquired (often they are not the same!),
- learning environments and their design and organization.

Additionally, didactics is concerned with the interdependence of these five elements.

With regard to TVET didactics deals with a specific area of training and education – the *work-process*. TVET for people who have to cope with the demands of modern workplaces and life-long learning must be related to the work-process and not, as it is usual, to technical science. The logic of technical science is the logic of engineers – not of workers. The state-of-the-art work-process is the resource for formulating the objectives and subjects of the learning and teaching processes. It is the most appropriate environment for learning and it determines learning methods such as self-reliant learning, team and project learning.

The didactic approach shown in Figure 12 clarifies that the work-process is the decisive factor for designing TVET.

The figure also reveals that Learn- and Work Assignments as core elements are surrounded by the methods, objectives, subjects and learning environments. This constellation is explained in more detail in the next paragraphs.

4.5.1 Objectives of learning in TVET

Objectives have to be deduced from the work-process. As mentioned above, the modern work-process can be described as a complete action.

Figure 13 shows the steps of the work-process structure and the hidden didactic structure in reference to it. All of the occupational competences for a K-worker (knowledge worker) explained in the chapters above are justified by the actions in complex work-processes.

Table 7: Didactics as a science of learning and teaching (Source: Spoettl)

Didactics as Science of Learning and Subjects Teaching	
Didactics is the science of learning and teaching and is concerned with...	Methods
	Objectives
	Subjects
	Organizational conditions
	Equipment conditions
... and their interdependence	

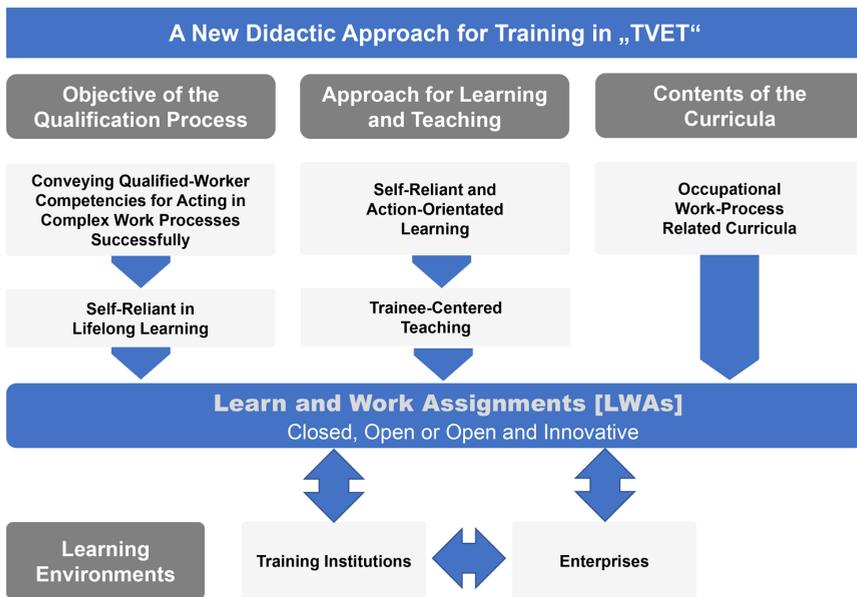


Figure 12: Didactic scientific approach for TVET (Source: Hoepfner/Koch/Spoettl¹²)

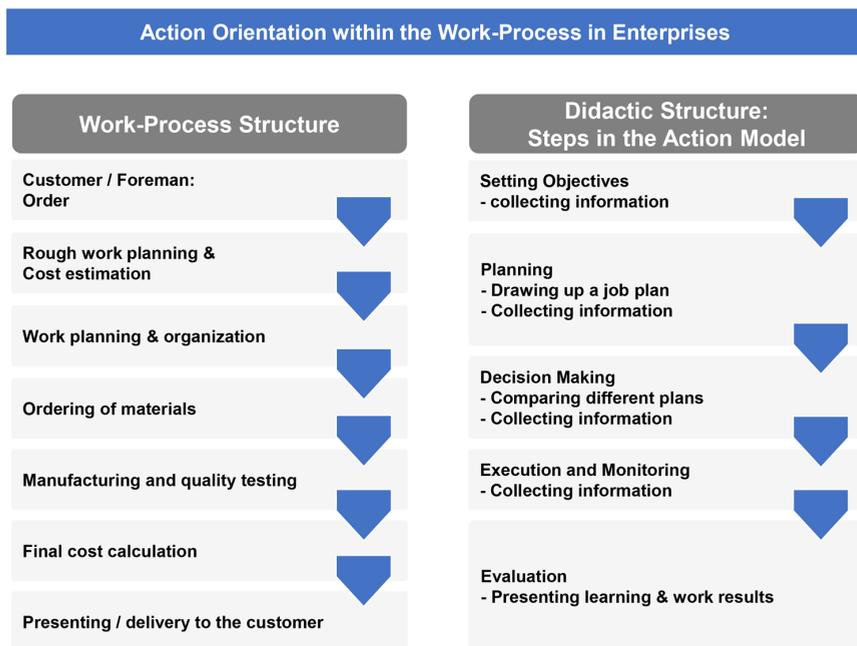


Figure 13: Action orientation within the work-process in companies (Source: Hoepfner/Koch)

12 The source is an unpublished slide selection.

Apart from the technical competences the work-process requires working in teams, for common planning, deciding, monitoring and evaluating (communication skills, mutual responsibility). The actions are often launched by problems and require self-reliant gathering of information. Self-reliance in life-long learning is made possible by learning successfully and efficiently during the completion of complex work-processes.

4.5.2 New subjects for TVET

Subjects for TVET can be determined by the analysis of complex state-of-the-art work-processes. Teachers and instructors can do this very easily by visiting companies concerned with production, assembling, maintaining, servicing etc. and to refer to the occupational subjects that they teach. Teachers have to look for work assignments/work-processes which

- deal with contents related to their given curricula,
- require planning, decision making, monitoring and evaluation (complete acting),
- require aspects of teamwork (e. g. team planning) or any teamwork at all,
- can be carried out within the training center (polytechnic etc.) or it can be shared between the training center and the company.

This method of gathering subjects may be only the first step in implementing a new TVET based on demands of the up-to-date work-processes, because it considers the given traditional or old-fashioned curricula. The tasks of the work-process are not formulated within these traditional or old-fashioned curricula. Here one can find a detailed description of skills deducted from work-processes and knowledge content deducted from technical science. The subjects described in current curricula are often obsolete by the time they are printed due to the rapid change of technology.

The didactic approach for TVET demands a new kind of curriculum (cf. Spöttl; Loose; Becker 2020). This does not mean that teachers and instructors cannot start practicing the approach before having new appropriate curricula. They can do it properly following the model of this module about the aspect of “methods” within the approach – about self-reliant learning. In fact the implementation of this new approach for TVET is a long-term process. It starts with changing the role of teachers, instructors and students within the TVET, with changing their habits and attitudes. This process of change leads to demands and pressure for changes in the curricula and the environment of learning and teaching.

4.5.3 Designing work-process related curricula for TVET

Work-process related curricula could be designed based on the results of expert skilled worker workshops. Workers from several state-of-the-art companies who have broad-based experience and are highly skilled should work as partners. The core work-processes which have to be identified are characterized as follows:

- can be found in a lot of companies operating in the branch/field,
- require complex action in teams or individually,

- describe the main requirements for a skilled worker in a determined area (occupation, job),
- are complex and comprise a lot of sub-tasks.

There are core work-processes which show an overview of the job/occupation during its performance and core work-processes which provide a deeper understanding of the conditions and requirements of the job/occupation. In the current context, the so-called light version, the workers describe the processes roughly, suggest a list of work-tasks and write them down. The list has to be approved by experts for TVET. Finally, the workers describe each work-process in a detailed manner. Items for this description are:

- content of work (e. g. inspection of functional reliability and quality of the single parts ...),
- tools (e. g. technical drawings, parts lists, sketches, machine tools, measurement equipment ...),
- methods/procedures (e. g. reading and producing technical documents, manual production methods, testing and inspecting the finished components),
- organization of work (e. g. third-party contractors/internal order, group work, centralised/decentralised labor management etc),
- requirements to be met by performed work (e. g. executing customer order in accordance with technical documents/models, following safety regulations, use of shop capacities, environmental protection regulations etc).

The core work-processes listed and the description of the work-processes, as explained above, form the new occupational work-process and they build a platform for the design of Learn- and Work Assignments in an ideal case.

4.5.4 Learn- and Work Assignments as core elements of TVET

Learn- and Work Assignments are the core elements in the didactic approach for TVET. They contain aspects from all elements and express their interdependence. Learn- and Work Assignments are assignments for the students designed by their teachers and instructors. They are closely related to assignments from a specific workplace (here: from the teacher). These assignments are prepared for the learning process with additional questions formulated to guide the quality development, the process of problem solving, hints for possible sources of information, orders for individual work or teamwork, sheets for self-assessment, orders for evaluation and presentation etc. The process of completing the Learn- and Work Assignments is a combination of physical action and thinking. Students acquire knowledge and skills while performing the task as self-reliantly as possible (the advanced more than the beginners). The practical and theoretical activities of the students are the focus of teachers'/instructors' activities. They consider: "How has the Learn- and Work Assignment to be designed in order to enable the student's efficient learning and work?"; "When shall I give advice and tips and when shall students learn without my support?"

The subjects for designing Learn- and Work Assignments are gathered by the teachers/instructors. Learn- and Work Assignments combine and integrate the learning and working environments. For example, students produce real work pieces in their training center, design circuits which can be found in the company's technology or plan their work in a learning corner at the actual company shop-floor.

The core element of the approach, the design of Learn- and Work Assignments, is explained as follows:

Learn- and Work Assignments

- relate to an up-to-date work-process or even to an up-to-date work activity in an enterprise or TVET center. The assignment should be described briefly, but clearly,
- include the customers' needs (e. g., appearance, color, material, strength, handiness, price or teaching and learning requirements), that
- TVET centers', enterprises' and society's needs as well as legal and environmental requirements,
- provide for the development of alternative solutions or solution ways,
- contain concrete timetables (deadlines to be complied with, for example) and the whole processing time,
- contain information on the type of collaboration (teamwork, partnership, group work),
- contain information that an overall final evaluation of the learning and working tasks will take place,
- contain information on documentation and reporting (also beyond the customer's/TVET center requests, if necessary),
- can contain specifications or education and training approaches and guidance as regards planning,
- can formulate support and thought impulses (such as: What sort of commitment does the process require? How can a learning process be supported? Is our manner of proceeding suited to the process? Is this solution the best one?).

4.5.5 Assignments on three levels of learning and working

Trainee-centered teaching is the basis for self-reliant learning. The Learn- and Work Assignments are the core elements of these teaching processes. These assignments have different levels of performance demand. We distinguish three levels as shown in Figure 14. Learners have to pass three levels in order to become self-reliant in their learning process with reference to assignments.

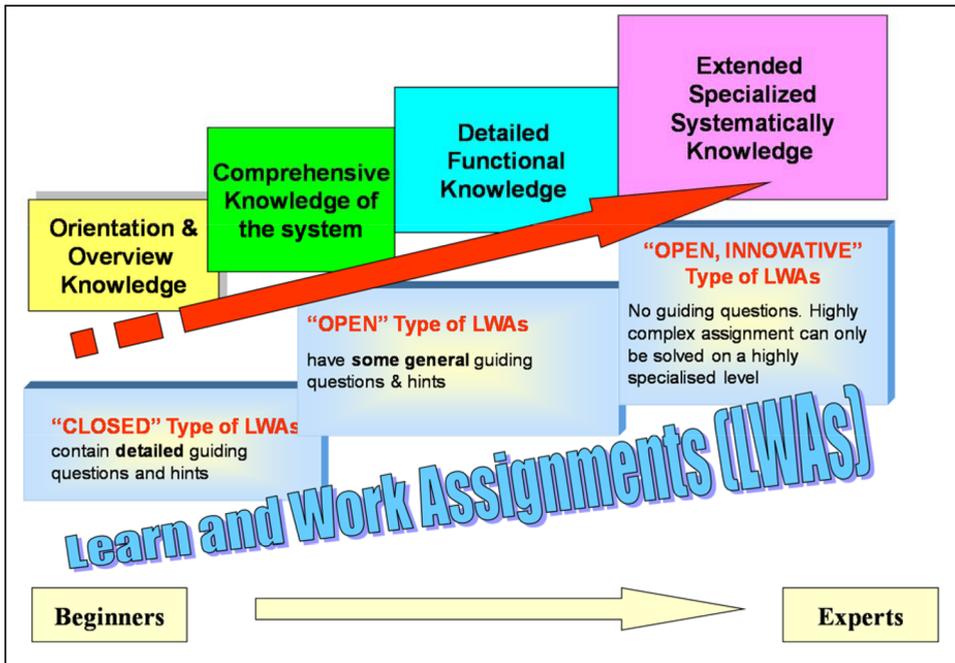


Figure 14: Various stages of self-reliant learning (Source: Spoettl)

"Open" assignments:

- These tasks require that the learners carry out a complete action including the finding and formulation of a goal in a given framework. The framework determines the scope for designing the goal (e. g. a number of alternatives, size of a product, timetable for manufacturing, available material). With this information, the learners are more motivated and they act with more commitment and responsibility for THEIR product. Students also learn how to plan steps for accomplishing goals acting entirely on their own or in teams, how to monitor their activities and how to evaluate the course of action and its result. They learn how to look for and get appropriate information independently, individually and how to gain information in a finely tuned cooperative process and to acquire knowledge, skills and attitudes for working in a specific field.

The teacher or instructor fosters acquisition of specific knowledge, skills and guidelines for communication and cooperation at this stage of self-reliant learning with more general and less specifically formulated aids. The latter depends on the performance level of the students and their progress in self-reliant learning.

Learners have to pass three stages in order to become self-reliant in their learning process with reference to assignments, and in addition to this, teachers/instructors have to teach increasingly as moderators, coaches and advisers.

“Closed” assignments

- These assignments require that the learner carries out the complete action in order to reach a given goal (set by the teacher/instructor). Students learn particularly how to plan steps for accomplishing given goals acting entirely on their own or in teams, how to decide on an appropriate approach/method, how to monitor their activities and how to evaluate the course of action and its result. In order to be able to accomplish this they learn how to look for and get appropriate information independently, individually and how to gain information in a finely tuned cooperative process. In addition to this they can acquire the required knowledge, skills and attitudes for working in a specific field.

The teacher or instructor can foster the acquisition of specific knowledge, skills, and guidelines for communication and cooperation with well formulated aids for self-reliant learning, such as guiding questions, orders, advice and assessment sheets.

“Open, innovative” assignments

- “Open, innovative” assignments are exceptionally “open” assignments. Everything that has been written on “open” assignments above is also true for “open, innovative” assignments except the fact that the framework for the goal is wider and that the trainees have to establish decision-making and evaluation criteria by themselves. These assignments are related to the organization of work. They are supposed to enable learners to actively participate in the organization of work. “Open, innovative” assignments must be designed in a manner that encourages trainees to ask themselves such questions as:
 - Why is the technique structured like this and why does the whole enterprise or the department use it in this form?
 - Why is work organized in precisely this way at this workplace? and
 - “Could the job be done in another way? What alternatives are there?”

The principal characteristic of these assignments is that the learners are asked to discover and use the instruments associated with work organization to accomplish the tasks, to seek alternative, innovative solutions, often through a teamwork approach, to evaluate the various proposals and, therefore, to become capable of making well-founded choices.

Teachers and instructors design the assignment and aids for the planning process. The use of independent problem-solving processes by the trainee teams for such complex tasks requires a teacher/instructor as coach. They have to coach the trainee who moderates discussions on the challenges of the assignment following a discussion scheme and they have to coach the trainee-moderated workshop in establishing decision-making and evaluation criteria. Coaching means here that the main activities have to be done by trainees and their team-leader. The teacher or instructor intervenes only if the team-leader faces serious problems during the moderation process, if it is necessary to provide trainees with additional information or if trainees forget important decision-making/evaluation criteria.

4.6 Self-reliant learning and trainee centred teaching

The self-reliant learning process for solving Learn- and Work Assignments follows the steps of the appropriate quality processes as well as the steps of the complete action, and the teaching process is focused on these steps. In this context, the teacher/instructor is no longer the master who provides information, shows everything that has to be done and explains everything. He/she is no longer the great supervisor who monitors all the students' activities and assesses them all the time. He/she concentrates on students' self-reliant learning while performing the action. He/she is not the old-fashioned master; he/she is an advisor and a moderator of students' learning activities. This is what trainee-centered teaching is about.

Figure 15 shows the steps of learning and working as a cycle with the following successive learning and working phases:

Setting goals

Students have to reach a given goal (according to the assignment) on their own or they have to come up with a goal by themselves. Coming up with their own goal in a Learn- and Work Assignment practical exercise and work assignment is related. For example: to developing their own version of a product, changing a given design in accordance with material available, developing technology for assembling or improving given tools, setting a time for assembling something or for quality improvement. The teacher/instructor sets a scope for the activities, material and time, gives hints to help them find their own goal (If the goal is given, the teacher/instructor has to motivate the students to take it on as their own).

Planning

Students plan the steps in a team or individually. They work on several variations of the plan. The teacher/instructor gives hints and provides them with information sources. Other teachers (e. g. of general studies) can give lectures on certain subjects and special assignments for acquiring appropriate knowledge.

Decision-making

Students select one of their plans and present the decision to the teacher/instructor and their colleagues. The teacher/instructor reveals mistakes and inaccuracies within the plan and gives advice regarding required changes.

Execution and monitoring

Students follow their work plan and monitor their activities and the results. For this purpose, they fill in monitoring sheets delivered by the teacher/instructor. Other teachers (e. g. of general studies) provide students with information appropriate for the execution and monitoring process. The teacher/instructor should intervene only if a dangerous situation occurs during the use of machines, if students do not follow health and safety regulations, if an appropriate result is jeopardized or if they are going to fall seriously short of the defined goal.

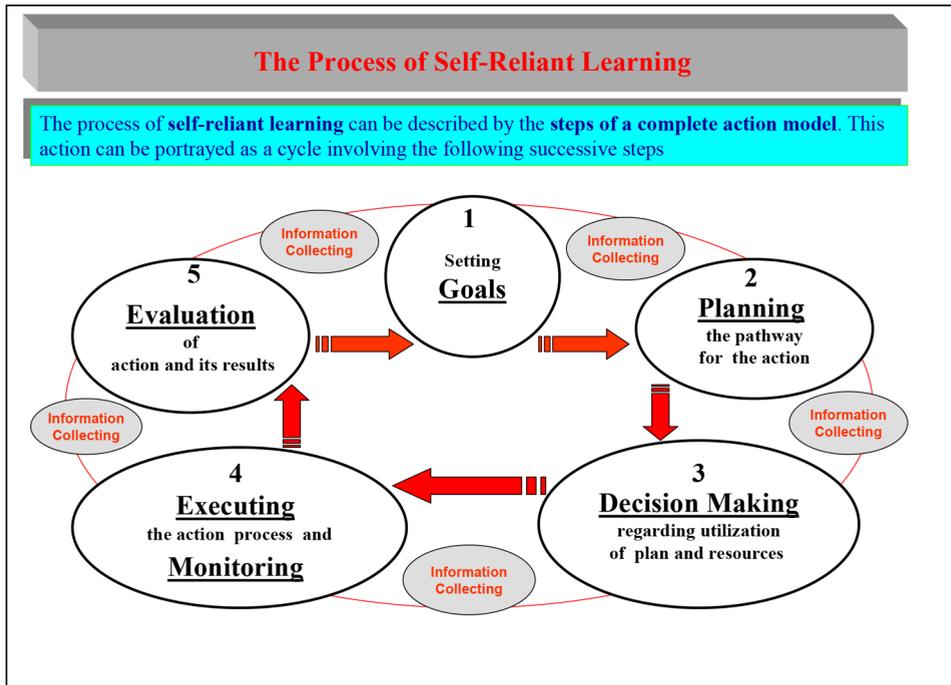


Figure 15: Cycle of self-reliant learning and working (Source: Hoepfner/Koch/Spoettl¹³)

Evaluation

Students initially evaluate themselves their entire approach to completing the assignment. They use a given assessment sheet designed by the teacher/instructor or by students themselves in cooperation with the teacher/instructor. This evaluation is double-checked by the teacher/instructor. Students also prepare a presentation of their learning and working activity and its results. Teachers in general studies support this by preparing lectures and special assignments.

4.7 Learn- and Work Assignments and trainee-centred teaching

4.7.1 Characteristics

In the previous chapter, we characterized the new role of teachers and instructors in trainee-centered teaching as the role of a moderator and advisor. This role will now be explained in more detail by comparing it with the old role.

The old role of the instructor is very accurately characterized by the so-called four stages method:

¹³ The source is an unpublished slide selection.

1st Stage (explaining/listening)

The instructor sets the goal of the training unit. He/she outlines the skills and knowledge accomplished after finishing the unit. The importance of the skills and knowledge which have to be acquired is emphasized – which means their importance for future learning processes and for the work-process as a skilled worker (motivation). He/she reminds the trainees of the skills and knowledge that they already have acquired and that these are related to the new skills and knowledge, and he/she gives an introductory lecture on the subjects *that have to be acquired*.

2nd Stage (demonstrating/watching)

The instructor names the individual steps of the task that has to be carried out and demonstrates each step while naming it. The trainees are asked to follow attentively. More information is given during the demonstration. In the case of complex skills, the trainees are requested to write down the named steps and the given information.

3rd Stage (correcting/imitating)

The instructor corrects the repetition of the trainees carefully. The trainees imitate the actions of the instructor as closely as they can. They explain what they do and speak aloud the names of the steps. Monitoring is the main activity of the instructor in this phase.

4th Stage (evaluation/practicing)

The trainees apply the acquired skills and knowledge to different work situations. The instructor evaluates the results: He/she describes the level of the skills, states the progress of the learning process and explains necessary improvements.

These four stages are appropriate for acquiring simple skills, but instructors also use the same methodology for the acquisition of complex skills. They often introduce complex practical tasks with lectures that take hours. Trainees have to listen to a lot of theory before starting with practical exercises. Instructors justify this by the need of *basic knowledge*, to be acquired before starting practical work. But this is only true with regard to basic knowledge necessary for carrying out the *first steps* in completing practical assignments. It does not deliver reasons for presenting complex theories needed for future phases of training and it seems that the above-mentioned instructors forget the weakness of the human mind. Mostly we can only keep in mind intentionally what we need now or something that leaves a strong impression. The instructors themselves are also unable to keep all the new information in mind that they will need the following week for a practical activity they have never done before. This is what teachers often expect from their trainees and they wonder why trainees ask a lot of questions referring to subjects that they heard in the introduction (but do not remember). It is much more successful and time-efficient if instructors and teachers give a short introduction to a subject and let the trainees act self-reliantly after that. Trainees can look for information (knowledge) on their own, and from time to time, teachers/

instructors can support the self-reliant completion of an assignment with lectures that go deeper and into more detail on the subject.

Trainee-centered teaching requires very active learners. Learners who get an assignment for self-reliant learning require all the activities given in the overview below:

Table 8: Comparison of teacher-centered teaching and trainee-centered teaching

Teacher/instructor centered teaching (Old Role of Teacher/Instructor)		Trainee centered teaching (New Role of Teacher/Instructor)	
Teacher/instructor is teaching by	Trainee is learning by	Teacher/instructor is teaching by	Trainee is learning by
Explaining	Listening	Designing learn- and work assignments and Guiding questions and hints. Discussing information results.	Self-reliant informing Presenting information results
Demonstrating how to do	Watching and imitating	Designing learning and work assignments and guiding questions and hints. Discussing plans.	Self-reliant planning Presenting planning results
Supervising and monitoring	Following instructions	Designing learn- and work assignments and guiding questions and hints. Giving advice and hints.	Self-reliant monitoring Self-reliant
Evaluating	Listening and accepting	Designing learn- and work assignments and Assessment sheets. Discussing the results and final assessment.	Self-reliant assessing Presenting results of all activities

The new teacher/instructor must challenge the learners to find their own way of doing things and their own solutions for given assignments. Teachers and instructors steer the learning process from the background, they intervene only if the practical exercise and work results are jeopardized or if trainees have problems which they can't solve by themselves (e.g. conflicts in their team). Normally they offer hints for self-reliant searching for information, for the consideration of particular information, for re-checking the plan and for thinking more carefully. New role of teachers and instructors e.g. those using the trainee-centered teaching approach) accept students' own methods of solving problems even though they might not be the most effective or efficient. It is the method the trainees found, it is their way and is associated with motivation to continue. They will find the disadvantages by themselves during the learning and working processes or within their final assessment.

Assessments during the activities for completing a certain assignment and at its end should be done by trainees before teachers/instructors do their assessments. Self-monitoring, evaluating and related assessments are core components of self-reliant learning and fostering its development is a primary objective of student-centered teaching. Self-monitoring, self-evaluating and self-assessing produce highly efficient results. The learners have a much stronger impression and more comprehensive memory of the experience and knowledge gained during the course of these activities because they were required to think about the benefits of knowledge and skills used, comparing alternatives of knowledge, the use of different knowledge and skills and estimating the usefulness of prerequisites. Assessing themselves strengthens their position within the learning process and leads to more self-consciousness.

It is very hard for teachers and instructors not to answer if they are asked by trainees for information which the trainees actually have to provide themselves. It is, however, much more appropriate to stimulate the thinking of the students in such situations than to answer the questions.

Self-reliant learning means: the trainees think as much as possible in the course of the process of completing the learn- and work assignments. Teachers/instructors have to support their thinking and not take away from it. They should always ask themselves the following questions:

- Could I have involved the trainees more in the preliminary planning of the assignment?
- Have I placed too little trust in the trainees?
- Have I relieved the trainees from too many responsibilities?
- Have I failed to provide the necessary help?
- Have my directives and instructions always been clear enough?
- Have I been too overbearing with my knowledge and skills?
- Have I monitored and evaluated too many things myself and made it difficult for the trainees to exercise their own judgment?

The following is a summary of guidelines for the teacher/instructor as a moderator and adviser:

- Stay in the background as long as you think it is appropriate.
- Do not answer every question.
- Offer tips for independent activities.
- Challenge the trainees to find their own way/solutions.
- Accept students' way of doing things.
- Stimulate the trainees' thinking wherever and whenever possible.

Emphasizing the new role does not mean that teaching by explaining and demonstrating is obsolete and that lectures by the instructor or teacher are no longer necessary. Quite the contrary: Under certain circumstances these "old methods" are highly relevant but have to be integrated into teaching methods following the student-centered approach.

4.7.2 Practical Issues

The characteristics of student-centered teaching can be summarized as (cf. Figure 16):

Teacher/instructor is moderator and adviser to the learning process.

1. Well formulated assignments (problems, tasks) for the learners are the emphasis of the teaching/training process.
2. Teacher/instructor supports learners' activities for finding their own ways, asking questions themselves, monitoring and evaluating their activities themselves and assessing their own performance level from the background.

Teacher/instructor fosters teamwork between the learners.

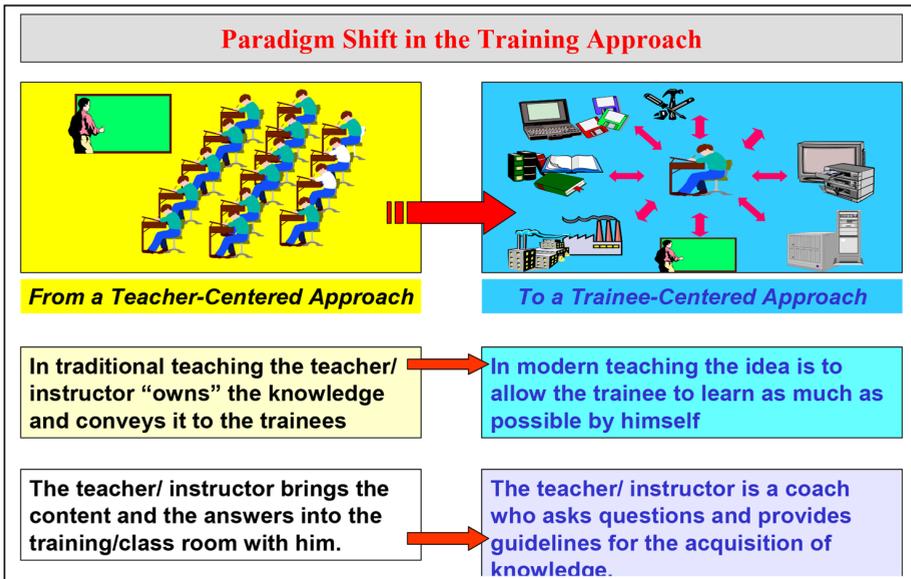


Figure 16: Summary – Paradigm shift in the training approach (Source: Hoepfner/Koch)

Literature identifies a great number of learning theories and educational theories. A small selection of frequently applied learning theories is sketched below.

Theories can help us to do things better, although ultimately the practical knowledge that we use in the world of work is tacit knowledge beside the explicit or theoretical knowledge. It is important that we do not lose sight of the importance of "doing theory" in a TVET college curriculum. In any technical or vocational area of expertise, theory is always theory that can improve practice. For example, here is an illuminating account of why theoretical knowledge of plumbing is important to help an industrial mechanic improve his skills:

The interconnection of the component parts of a machine structure is an obvious notion, but to grasp the meaning of the interconnection for your own action, and to realize that what you do can extend over various kinds of materials or functions, and can be close by or at some distance.

Such an understanding can give rise to deliberation: a stop-and-think orientation but not enough as a theory. In TVET, the practical know-how and the know-that, the vocational competence is also very important.

If we recall an experienced industrial mechanic or other occupations, facing a somewhat more complicated situation of this type, saying, "It's as important to say 'no' ... as to say 'yes'. You can get yourself in real trouble if you don't think it through. The comprehension of a machine or machine unit as a complex system of materials, processes, and forces is not an obvious way to think about a production process. The good industrial mechanic has a diagnostic frame of mind. For example, the problem of an electrical connection that does not completely stop energy flow can be explained by a number of possible causes. An industrial mechanic must consider and test each possibility in turn: a kind of industrial mechanic's differential diagnosis. Could it be a bad washer? How about rust, mass connection of the electrical wire? To think in this way you need to know how a thing is put together, how a device, or category of devices, works. You may not be familiar with a particular brand of a connection, but if you can determine whether it's a correct electrical connection, then you'll know something general about its components and how they function. Then you're able to go through these steps in your mind. A lot of tacit knowledge helps the plumber – the mechanic in this example - in the diagnostic process (cf. Moll; Steinberg; Broekann 2005).

The theory for an industrial mechanic works as follows:

1. It allows him to understand the connections between different elements of the machine system, or the network of principles according to which an electrical system can function. This allows him to diagnose problems more easily, and to understand how things need to be repaired.
2. The combination of theoretical and tacit knowledge allows him to understand categories of mechanisms – connection, resistance, energy flow, etc. – and thus to make generalisations in the context of a machine system, and this again helps him to repair things. He/she can draw on knowledge which is not necessarily directly in evidence as helpful for solving a particular problem.

4.8 Learning theories

Against this background, self-reliant learning and the trainee-centered approach have been shown from a pragmatic point of view. We have also shown possible ways of implementation. This approach is supported by different learning theories with different points of view. Three of the most common learning theories are briefly described with a perspective of their central targets.¹⁴

Above are explanations of the different ways in which we can think about the networks of knowledge that we find in a technical and vocational education environment. We have seen that there are networks of tacit and theoretical knowledge and

¹⁴ The discussions are oriented to the following publication: Moll, Ian; Steinberg, Carola; Broekann, Irene (2005): Being a Vocational Educator. A Guide for Lecturers in FET Colleges. South African Institute for Distance Education (SAIDE). First Published 2005. Modifications are made by Spoettl, 2019.

experience that skilled practitioners carry around with them, in their minds and bodies, that allow them to make skilled judgments about their craft without necessarily being able to put this into words. We have also seen that there are important tacit dimensions of craft knowledge that are distributed across them, the tools they use, and the environments in which they operate. There are also networks of theoretical knowledge – expressed in language and written.¹⁵

We need to examine how these different kinds of knowledge are learnt. For this purpose, we look at three different theories of learning, each of which has been enormously influential and gives us a particular insight into what learning is and how it takes place. We shall use each one of the theories in order to describe how technical and vocational know-how is acquired. The three theories in question are:

- Jean Piaget's theory of equilibration,
- Lev Vygotsky's theory of mediation,
- Jean Lave and Etienne Wenger's theory of communities of practice.

We will not try to suggest that one or other of these learning theories is better than the others. Rather, that each one of them gives us a particular insight into learning. In Wenger's words, "There are many different kinds of learning theory. Each emphasizes different aspects of learning, and each is therefore useful for different purposes."

4.8.1 Jean Piaget: The theory of equilibration - "acting to know"

We often recognize that human beings are naturally curious about the world around them. They constantly engage with the world around them in order to find out more about it, ask questions, make up hypotheses, imagine new possibilities, etc. In other words, human beings actively construct their own knowledge and make use of it. All of this seems to be motivated from within, and constitutes an important source of explanation of learning.

Perhaps the most important theorist of this kind of learning process was Jean Piaget (a Swiss scientist, 1896–1980). He advanced a conception of learning known as the theory of equilibration. Piaget describes learning as follows:

To know an object, to know an event, is not simply to look at it and make a mental copy or image of it. To know an object is to act on it. To know is to modify, to transform the object, and to understand the process of this transformation, and as a consequence to understand the way the object is constructed. An operation is thus the essence of knowledge, it is an interiorized action which modifies the object of knowledge.

What does Piaget mean by this? The core of his theory of learning is the recognition that we learn from our actions (operations) on the world. The very fact that we are alive means that we are always acting on the world. On the one hand, we act on the environment by interpreting it and coordinating its features so that they fit with our existing knowledge. Piaget called this *assimilation*. But, simultaneously, the objects in our environment (for example, an article to be manipulated, an image to be perceived, a tool to be used, a person to be understood, a task to be carried out, or a problem to be

¹⁵ The author has identified comparable situations in the car sector in a number of empirical research projects.

solved) demand more complex actions, and so we must also constantly change ourselves in order to be able to deal with the new knowledge inherent in the universe of objects. Piaget called this *accommodation*.

You can see here that in any learning there is a tension (a lack of balance, disequilibrium) between what we already know how to do it and what the world requires us to do. It is in action how a student responds to this, by regulating himself to produce a new equilibrium in the form of a more sophisticated understanding of the world. This impulse of self-regulation is called equilibration by Piaget– it is made up of the simultaneous processes of assimilation and accommodation. Crucially, as a student engages in these actions, he/she becomes increasingly aware of them, or the new forms of coordination, integration and transformation of knowledge that they entail, and his/her understanding of them grows. Ultimately, he/she internalizes his/her own actions as new forms of understanding and knowledge. Therefore, as he/she works with the tools, he/she makes certain adjustments, including the way he/she stands, the way he/she holds the tools, the depth and extent of cuts that he/she makes into the wood, and the amount of force on or active guidance of the tool he/she must apply. He/she tries out various options, some of which seem to be suggested by the wood as he/she works, some of which he/she thinks about more clearly as he/she encounters problems. He/she is not always sure of what will happen, but the actions he/she is engaged in with the tools seem to suggest to him/her what to do (accommodation).

Once he/she tries something new with the tool and recognizes that it is working, he/she practices it and consolidates it. It becomes part of what he/she now knows, somehow built into her very being through the experience. (The overall culmination of the process of equilibration, which has been going on through all the various phases in his/her work.)

The theory of equilibration (background)

Jean Piaget developed a theory of knowledge and the cognitive processes whereby people come to know the world. From Piaget's perspective, all knowledge is constructed through our action in the world. He argued that we can only know about things if we act on them. Very small babies get to know the world around them by touching and tasting things – all mothers get exasperated by their children constantly putting things in their mouths! As the child gets older, she literally gets to know her world by moving about in it, learning to crawl and then walk, moving about and bumping into things, learning what's hard and what is soft, grabbing things, and learning what's heavy and what's not. Furthermore, Piagetian theory shows that action continues to be very important for all thinking throughout our lives. Older children and adults, too, use action to know the world. Sometimes these actions may be physical like those of the small child, but more often they do not have this quality, the action increasingly happens in the mental realm. Piaget explains that the development of knowledge occurs through the process by which we seek a state of equilibrium or balance between our previous knowledge and new things we encounter in the world. We understand new things by seeking a balance between the known and the unknown. We all mentally adjust and readjust our thinking in response to new objects and events, actively weighing up and

balancing our knowledge and moving forward. Piaget identified two mental processes that enable us to perform this balancing act: assimilation and accommodation: Knowledge of an object does not consist of having a static mental copy of the object but of effecting transformations on it and reaching some understanding of the mechanisms of these transformations. An intelligent act consists above all of coordinating operations, uniting, ordering (in the sense of introducing order), etc. These operations, which derive from the subject's internalization of his own actions, are the instruments of the transformations that knowledge is concerned with.

Logical relationships are, first and above all, operational structures. Although their most advanced forms are certainly expressed by language, their origins are found in the co-ordination of the subject's own actions. Even at the sensorimotor, pre-verbal level, a child is involved in activities that include uniting, ordering, introducing correspondences, etc. and these activities are the source of operations and logico-mathematical structures.

Knowledge is not determined strictly by the knower, or by the objects known, but by the exchanges or interactions between the knower and the objects (between organism and the environment). The fundamental relation is not one of simple association but of assimilation and accommodation; the knower assimilates objects to the structures of his actions (or of his operations), and at the same time he accommodates these structures (by differentiating them) to the unforeseen aspects of the reality which he encounters.

There may be something, however, that this Piagetian perspective on learning may be missing. Perhaps another theory of learning can give us more insight into this.

4.8.2 Lev Vygotsky: The theory of the social construction of knowledge and cognitive processes

Vygotsky (Russian psychologist, 1896–1934) developed a theory of the social construction of knowledge and cognitive processes. He was particularly interested in the way that human beings learn in social relationships with other people. This led him to investigate the importance of learning at schools or other educational institutions for our overall development as human beings in contemporary society. Part of Vygotsky's contribution was his account of the mediator-learner (or teacher-student) relationship, the way it provides the conditions for new learning to occur, and, on the basis of this learning, for the student to develop new forms of understanding. We can all remember mentors or teachers who made a particularly important contribution to our own learning and development: Vygotsky's theory provides us with an understanding of exactly how and why such mentoring is so important for learning.

Vygotsky's best-known concept is the zone of proximal development. By this he means the space within which all meaningful learning takes place – the space between what the student already knows and can do by himself/herself, and what he cannot do on his own but can do under the guidance and with the support of someone else who is more skilled and knowledgeable. You can see why the idea of mediation is so important in his thinking – it is the activity that takes place between two people that makes learning possible and that explains learning. Here are two definitions of the *zone of*

proximal development put forward by Vygotsky. The first allows us to understand how the prior knowledge of the student makes new learning possible:

- The zone of proximal development defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state. These functions could be termed the “buds” or “flowers” of development rather than the “fruits” of development.
- The second definition allows us to understand how the relationship with a mentor makes new learning possible: The zone of proximal development is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

Vygotsky would not necessarily disagree with Piaget’s theory, but he would argue that Piaget, by treating them as equivalent to the other categories, is somehow missing the crucial point about learning from other people. Other significant people in the child’s life (on first place the mother) mediates the cultural aspects of various objects – like a hammer, a typology of snakes and lizards, tea, soccer, books etc.

The theory of mediation (background)

Lev Vygotsky introduced us to the notion of teaching as mediation. A teacher (here we can include a schoolteacher, a lecturer, a master craftsperson, an adult caregiver, a more experienced colleague, etc.) is seen to mediate, or to interpret and pass on to the student, the knowledge that a community has built up over time. Vygotsky put forward the notion of the zone of proximal development to model how it is that teachers mediate new understandings. For him, there are two levels of development that exist simultaneously in a developing child: the actual level of development, which is manifest in what the child can do without help, and the potential level of development, which is manifest in the child’s abilities with optimal guidance from a teacher. The gap between these two levels of development is the zone of proximal development, and it is obviously an enormously useful contribution to our ideas about learning.

The essential difference of a child [when compared with the way an animal learns] is that he/she can imitate a number of actions which go beyond (“depass”) the boundaries of his own potentiality, if not to a limitless extent. With the help of imitation in collective activity, under adult guidance, the child does much more than he/she can do with understanding, independently. The divergence between the level of performing tasks which are accessible under guidance with adult help, and the level of performing tasks which are accessible to independent activity, defines the zone of the child’s proximal development.

What the child can do today with adult help he/she will be able to do independently tomorrow. The zone of proximal development therefore allows to determine the child’s next steps, the dynamics of his/her development, to consider not only what development has been brought about but what will come about in the process of maturation.

4.8.3 Jean Lave and Etienne Wenger: The theory of learning in social relationships

Lave (an anthropologist) and Wenger (a social learning theorist who both work in California, USA) have put forward and developed a theory of learning that describes it in terms of the *social relationships* that are necessary for new understandings to occur. It is a social theory of learning, in distinction to those of Piaget and Vygotsky, which are psychological theories.

Central to their theory is the idea of a *community of practice*. People engaged together in a particular activity form a community of practice. Examples of such a community are the following:

- a group of shop-floor technicians working on similar problems,
- a network of computer programmers and technicians in a large IT company who meet periodically and communicate regularly online in order to explore novel software solutions,
- a gathering of first-time learnership candidates in a factory helping each other cope,
- a group of learners who hang out together and support each other in the work they do at school, and
- a group of lecturers at an FET college who meet regularly over lunch and informally discuss their students, what they teach, and how they do assessment.

In short, a community of practice is a group of people who share a concern, even a passion, for something they do together and who interact regularly to learn how to do it better.

Collective learning is thus the focus of Lave and Wenger's theory. The members of a community of practice continually build relationships that enable them to learn from each other. They take part in cooperative activities and discussions, help each other, share information, and together develop new understandings of technical knowledge in their field. Together, they create a system of shared ideas, commitments and memories. They develop resources such as tools, texts, specialist terminology and routines that in some way contain the expertise of the community. However, a community of practice involves much more than the knowledge or skill associated with fulfilling some tasks. Because members are involved in an ongoing set of relationships over time, the community of practice develops a strong sense of joint enterprise and identity.

The theory of communities of practice (background) The following extracts are taken and a little modified from Etienne Wenger's book, entitled *Communities of Practice: Learning, Meaning and Identity*:

The primary focus of the theory of communities of practice is on learning as social participation. Participation here refers not just to local events of engagement in certain activities with certain people, but to a more encompassing process of being active participants in the practices of social communities and constructing identities

in relation to these communities. Participating in a playground clique or in a work team, for instance, is both a kind of action and a form of belonging. Such participation shapes not only what we do, but also who we are and how we interpret what we do. A social theory of learning must therefore integrate the components necessary to characterize social participation as a process of learning and of knowing.

These components include the following:

- **Meaning:** a way of talking about our (changing) ability – individually and collectively – to experience our life and the world as meaningful.
- **Practice:** a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.
- **Community:** a way of talking about the social configurations [for example, workplaces, institutions, professional societies] in which our enterprises/institutes are defined as worth pursuing and our participation is recognizable as competence.
- **Identity:** a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities.

The negotiation of meaning is a fundamentally temporal process. Some communities of practice exist over centuries – for example, communities of artisans who pass their craft from generation to generation. Some are shorter-lived but intense enough to give rise to an indigenous practice and to transform the identities of those involved. For instance, such communities may form as people come together to handle a disaster. The development of practice takes time, but what defines a community of practice in its temporal dimension is not just a matter of a specific minimum amount of time. Rather, it is a matter of sustaining enough mutual engagement in pursuing an enterprise together to share some significant learning. From this perspective, communities of practice can be thought of as shared histories of learning.

If practices are histories of mutual engagement, negotiation of an enterprise, and development of a shared repertoire, then learning in practice includes the following processes for the communities involved:

- **Evolving forms of mutual engagement:** discovering how to engage, what helps and what hinders; developing mutual relationships; defining identities, establishing who is who, who is good at what, who knows what, who is easy or hard to get along with.
- **Understanding and tuning their enterprise:** aligning their engagement with it, and learning to hold each other accountable to it; struggling to define the enterprise and reconciling conflicting interpretations of what the enterprise is about.
- **Developing their repertoire, styles, and discourses:** renegotiating the meaning of various elements; producing or adopting tools, artefacts, representations; recording and recalling events; inventing new terms and redefining or abandoning old ones; telling and retelling stories etc.

5 Transfer of the Training Concept into Training

In order to create a successful framework for the transfer of the module contents (cf. Chapter 3), the modules on “learning outcomes” have been defined in a second step. Thus, the competence level to be reached was defined as well as the knowledge and skills to be acquired by the students enabling them to carry out their own work. Experts who were able to evaluate which level was realistic for the respective target group participated in this step. These considerations then influenced the determination of the “prerequisites”. The “didactical comments” provide hints as to which didactical approaches could be successful for the development of competence. Methodological recommendations concretize this process. The most important aid for the didactical transfer are the Learn- and Work Assignments (LWA) which are presented in detail below. There can also be found an explanation of the development of LWA.

With the objectives of equipping participants with the Industry 4.0-technical content and innovative teaching and learning methods such as self-reliant learning and project-based learning, the training of multiplier approach is designed and organized to teach key concepts and skills related to particular topics in each training module. The changes due to technological revolution, Industry 4.0 and digitalization will be taught with the help of self-reliant learning and innovative teaching methods. *The training of multipliers will pave the way to building communities of practice among TVET personnel from regional and national organizations and ongoing peer learning.*

The training modules “Fit for Industry 4.0” are designed to closely syndicate technical skills, innovative learning and teaching methodologies, laboratory works, technical and practical assignment and training organization together.

At the end of the training, participants have:

- gained technical competence and knowledge through smart factory training,
- acquired competence in developing strategic didactical projects,
- raised awareness for cooperation with industry through company visits and invitations for sharing experience.

By the last day of all 5 training modules, the participants have proven to be sufficiently equipped with the competences described in the Learn- and Work Assignments (LWA) curricula through a presentation of the country training plan.

This training also enables participants to select approaches and adapt best practices for their own country.

Based on the national implementation plan shared in the training, it can be seen that every country is very committed to transferring the knowledge gained to other TVET teachers at home.

5.1 Concept of Learn- and Work Assignments for teaching and learning

In the ASEAN Region, Quality Assurance (QA) and Quality Development (QD) in Technical Vocational Education and Training (TVET) have high priority. These two pillars should support quality improvement as the key to the advancement of TVET systems. Apart from measures taken at the institutional level, the ASEAN Qualifications Reference Framework (AQRF) and the East Asia Quality Assurance Framework (EAQAF) are two instruments with the potential to support quality development processes and to contribute to harmonization and quality standards in the ASEAN region (cf. Euler 2018). The successful implementation of:

- ASEAN Quality Assurance Framework (AQAF) and the
- East Asia Quality Assurance Framework (EAQAF)

which have been developed over the last decade and were approved or recognized by ASEAN countries require efficient instruments. They should be the focus of further development.

The AQRF serves as a reference point and aims to provide a common reference framework within the countries. Quality frameworks are of some help in achieving harmonization between countries. They provide not only a fair and mutual recognition of competences for the mobility of a workforce within the qualification system, but they also help to promote higher quality TVET.

When it comes to quality, development and improvement, the AQRF might be used as a reference framework for certain quality levels which are relevant for assessment. With regard to Quality Assurance, a conceptual design for an East Asia Summit TVET Quality Assurance Framework (EAS TVET QAF, short: EAQAF) already exists and is ready for implementation. The EAS TVET QAF offers a set of principles, standards and quality indicators to assess the quality of the TVET systems of the countries and provides a basis for a greater alignment of national TVET systems (cf. Bateman et al. 2012).

One of the main questions is how to operationalize the existing frameworks into an instrument for Quality Improvement and Quality Assurance.

For education and training of teaching staff, topics of modules have been created (in two workshops), and these form the platform for the planning of training. The requirements of the qualifications and assurance frameworks are respected in the planning. Apart from this, some remarks are made on the delivery process (didactical comment, learning environments, teaching methods etc.) of the modules.

As a support to the delivery process and the mode of learning and teaching, a didactical framework will be offered which is based on so-called “Learn- and Work Assignments” (see Chapter 4). LWAs are the “key instruments” for teaching and learning within the modules.

LWAs fulfill two functions:

1. they define the detailed curricula of the modules and
2. they are very helpful instruments for the didactical design.

In order to ensure that LWAs dominate and describe the curricular framework of a module, they should be carefully chosen in order to fulfill this function.

LWAs are suitable as didactical instruments or teaching aids because they are useful if adequately described for the methodological shaping of the learning and teaching process. It will be up to the trainers to decide on the respectively adequate implementation methods.

5.2 Learn- and Work Assignments as supporters of quality

Learn- and Work Assignments are core elements of the didactic approach for different requirements of TVET. They contain aspects of all work-related subjects, subject matter elements, Quality Assurance requirements and formulate their interdependence. Learn- and Work Assignments are assignments for the students designed by their teachers and trainers. It is necessary to design learning events, which provide an opportunity for the students to find appropriate solutions for the problems they encounter. We call these arrangements “Learn- and Work Assignments” (LWA). LWA are core elements of didactical planning of the transfer of the contents of modules within the teaching process.

They are closely related to assignments at the workplace on the one hand and to subject matters on the other. In a specific situation, assignments are taken from a specific workplace. These assignments are prepared for the learning process with additional questions formulated to guide the problem-solving process, with hints to possible sources of information, orders for individual or teamwork, sheets for self-assessment, orders for evaluation and presentation etc. The process of completing the Learn- and Work Assignments is a combination of physical action and thinking. Trainees acquire knowledge and skills while solving the assignment as self-reliantly as possible (the advanced students more than the beginners). The practical and theoretical activities of the trainees are in the focus of teacher activities. These consider:

- How does the LWA have to be designed for efficient learning and work done by the trainees?
- How do LWA support quality?
- In which case do I have to be an adviser and in which case do the trainees have to learn self-reliantly?

The subjects for designing LWA are gathered by the teachers as explained above. LWA combine and integrate the learning, scientific and working environments. For example, trainees produce real work pieces in their training center, design circuits which can be found in the companies or plan their work in a learning corner on the actual company shopfloor.

With the help of the LWA, the trainee/student is expected to develop his or her capacity beyond professional (re)action to a capacity where he/she is able to shape the

dimensions of a given situation on the basis of broad competence, encompassing professional/technical, human/social and methodical/learning aspects.

The continuously increasing complexity at the workplace due to digitalization needs a workforce who is able to deal with the work-processes. Work-processes include all different challenges resulting from:

- technology,
- work organization and
- demands for quality.

If the employees master the work-processes, they can also master the respective technology of the predominant kind of work organization and will be able to perform quality work. However, they have to be trained specifically in order to meet these challenges.

State-of-the-art production today requires best quality of work based on customer requirements – and as quickly as possible. TVET centers have to prepare all their students for these demands. This will only be possible via quality-based training. The centers as a whole and the staff of TVET centers have to be prepared for this situation. This means:

- TVET centers have to create a framework which allows quality based-training,
- the entire teaching staff has to be able to assist the students to move up to the highest-possible quality output in order to take over the new role which is expected of them.

The future workforce needs the competence to critically judge and assess the work-processes and the related technologies. Workers have to ask and to answer such questions as:

- Why is technology structured like this and why is it used in this form at my workplace?
- Why is work organized in precisely this way at my workplace?
- Could the job be done in another way? Which alternatives exist?

Establishing a culture of quality in TVET is supposed to include these questions. Students should be encouraged to seek answers to these questions within the framework of their learning and work-processes.

LWA are instrument that allow for working with different methods supporting creative process towards quality and innovations as key elements of today's industry.

5.3 Developing Learn- and Work Assignments

For the operationalization of LWA, a careful step-by-step process should be followed which is outlined below. The first important step for developing LWA is the generating of LWA from the description of the contents of the modules and their expected output. This means that the overall quality orientation of a LWA depends on the quality which is defined via the output of the module description.

In selecting the LWA, it has to be noted that they have to cover the requirements and they must be action-oriented, yet preferably also have a shaping-orientation beyond the involved action. In order to determine whether a given assignment contains the quality of a shaping-orientation, we need to ask the following key questions:

- Why is the situation as it is (the product, the service, the technical facts, the technical solution, the tools, the work, the process, the organization etc.)? and
- Are there any other possibilities?

Such questions serve as guidelines for the selection of LWA. Some more details of this procedure are described in steps 1 to 4:

Step 1: Criteria for the selection of LWA

- Is it possible to organize the LWA around active involvement or projects?
- Do the LWA support as many of the apprentice's skills as possible?
- Are the LWA discernibly relevant for the organization of the enterprise and its area of business?
- Are there different ways of resolving or of carrying out the task?
- Are the LWA clearly limited in time?
- Do the LWA have a clear relation to training in general?

Step 2: Criteria for the selection of shaping-oriented LWA

- The formulation of the task stimulates action.
- The task gives scope to the arrangement, which can and must be used for the solution.
- Different ways of resolving and carrying out the task are permitted and are to be discussed and assessed.
- The efficacy of the action and solution is part of the assessment.
- The drawing up of an assessment concept by apprentices and trainees is part of the task.
- Working in groups plays an important role.
- The formulation of the task does not contain a work plan, but only the description of the learning product and the work and learning conditions.

Step 3: Establishment of LWA in line with the following considerations:

- There are possibilities for active participation whilst carrying out the task.
- Projects can be vehicles for active learning processes.
- Learning prospects should be considered.
- The tasks of the trainer should be taken into account.
- There are possibilities for learning at the given learning place.
- Media are available to support the possibilities of learning and acting.

Step 4: Carrying out the tasks/project and the LWA

- Planning is to be undertaken by the persons involved.
- Tasks/projects are separated into different categories.
- Alternative planning and work tasks which are structured differently while sharing the same aims are developed.
- The chosen model of action is selected and explained.
- Learning and project tasks are distributed.
- Tasks/projects are undertaken by the persons involved.
- The results are assessed by the people involved.

With regard to the development and operationalization of Learn- and Work Assignments, it is recommended that teachers/instructors and other teaching staff get involved in designing LWA within the framework of participatory curriculum development.

The LWA generated from the module description form the backbone of the curriculum. Seven core actions are relevant to develop the LWA:

1. Based on the module description, the LWA should be generated by a group of teachers and subject experts. Trainees might be members of such teams if applicable. This ensures a participative approach.
2. An expert group should respond to the draft of the LWA with recommendations to optimize it.
3. The defined outcomes of the module are the bases for generating LWA. In some cases, a group of outcomes forms the basis of a module and in other cases one outcome forms the basis for the generation of steps.
4. The content of the module gives a first orientation for possible grouping of the outcome.
5. The type of LWA which are designed can focus on very specific or more open questions. This offers various stages of a (self-reliant) learning process.
6. The design of LWAs can be manifold: offering a background for projects, for open learning, for close topics etc.
7. If required, the description of LWA can be changed in order to follow the latest requirements and to develop shaping competences.

LWA are the backbones of curricula and form the syllabus, while also offering a wide variety of learning modes which makes them a flexible didactical tool.

As LWA will be developed based on the pursued concept, selected modules and their overall structure are presented below. The module descriptions and the learning outcomes will be given priority. They form the core for the design of LWA and define the quality level. The module description has to be formulated in a short and meaningful way and should mention the planned quality level. Based on the statements given in the module description, the main core areas of the contents of the respective module are determined. The contents and the module description form the platform for the definition of the learning outcomes. The definition of the learning outcomes must

precisely name the learning results. The three priorities – module description, learning outcomes and module contents – form the core of a module. As a rule, all expert groups spend a lot of time with the formulation of these priorities both in a factual and thorough way. The other priorities such as title of the module, target group and prerequisites have to be formulated in such a way that it will be clear who is addressed by a module. The priorities and the learning environments can only provide an orientation how to learn and how to teach during implementation. As there are many factors of influence (e.g. teachers' knowledge of methodology, equipment of TVET centers, reflection level of the teaching staff and others), it is first and foremost the teaching staff who decide on the repertoire to be applied for the implementation.

After the presentation of the modules described below, explanations will be given on how the LWA can be generated. LWA have been designed with the aid of the formal process mentioned earlier, LWA which will be optimized with the help of experts of the community within expert workshops. This optimization phase was first and foremost used to safeguard the contents and to differentiate the LWA.

The modules, the generation of the LWA and their description follows below.

5.4 Description of Module 1

Module 01 TT – Innovative Teaching and Learning for Industrial Changes due to Industry 4.0	
Training Module Title	Innovative Teaching and Learning for Industrial Changes due to Industry 4.0
Responsible Person	NN
Target group	Teachers, Trainers, Instructors, Managers
Module Description	<p>The 4th Industrial Revolution (Industry 4.0) has affected every aspect of the world of work. In literature, the term “disruption” is widely used to represent these changes.</p> <p>The impact of Industry 4.0 is manifold. All the working areas in a smart factory are confronted by new working opportunities offered by using Cyber Physical Systems and the changes in work-processes and work organization. Dealing with a number of different data formats, high quantities of data, cloud computing, data safety and data mining are new dimensions of work on the shop floor with which everybody is confronted.</p> <p>This module will introduce the changes going on based on lean production and will create a deeper understanding of the impact on skilled work, thus creating awareness of the workforce required for Industry 4.0. It will also introduce the use of different data, the different safety systems and the use of IT safety systems to make work safer.</p> <p>The impact and possible consequences of the industrial changes because of Industry 4.0 for TVET and TVET management will be the main focus of this training programme. Awareness of the impact of the technological changes on teaching and learning will also be prepared and discussion on innovative teaching and learning for industrial changes will be initiated and integrated in the entire training deliveries.</p>

Module 01 TT – Innovative Teaching and Learning for Industrial Changes due to Industry 4.0	
Module Prerequisites	<p>TVET educators/teachers/instructors/trainers as well as managers with relevant technical background are the expected target group.</p> <p>At least two years of working experience in vocational education and training or at least two years of relevant industrial experience.</p>
Learning outcomes	<p>The participants will be able to</p> <ul style="list-style-type: none"> • explain the terms digitalization, Industry 4.0, 4th Industrial Revolution, Cyber Physical System (CPS), disruption, etc., • analyze and interpret the paradigm changes happening in industry because of the implementation of Industry 4.0, • elaborate the economic goal behind Industry 4.0, • analyze what lean production means and what the implications for the organization of manufacturing and other relevant areas, e. g. agriculture and services industry, are, • explain the new level of technical - and software-based communication – according to different data formats – between the Cyber Physical Systems and the internet or internet of things, • describe the technological and organizational changes of the work-processes in industry, • demonstrate how to use IT instruments in the work with automated systems and within the education and training processes, • demonstrate how to work with the different types of data formats and data safety systems and ensure safety, • solve various issues dealing with the content of embedded systems, including their operating systems, • elaborate and demonstrate how to use different didactical approaches that enable students and apprentices to work freely, self-reliantly and be problem-oriented, • facilitate autonomous development of specific technical skills needed for handling of the different media measures, instruments, that in most cases are learned through experience, • make use of soft skills needed for a digitalized world, especially competence in networking and communication, • deal with stress tolerance, flexibility, the absolute knowledge of the industry, keeping updated, language skills, • plan and deliver lessons by using innovative teaching methods/technology such as simulation, role-playing, portfolio development and problem-based learning (PBL) etc., • assess students' performance in the era of a digitalized world. <p>These innovative teaching-learning approaches will be integrated into all training deliveries.</p>
Module content	<p>Major topics that will be covered during the course:</p> <ul style="list-style-type: none"> • terms, introduction to industrial change, change of work, new technology and knowledge, • impact of Industry 4.0 on changes to the digital work environment at the shop-floor level, • wider usage of Internet in the work-processes of mechatronics systems and other relevant areas, e. g. agriculture and services industry, • data availability of sensors, actuators and process data in production systems: production planning system (PPS), manufacturing execution system (MES), supervisory control and data acquisition (SCADA), enterprise resource planning (ERP), SAP - System Applications, Products in data Processing, • data handling: saving data, cloud computing, data security, data mining, • structure of technical networks and transfer of big-data, • the smaller series and individualized production, executing frequent diverter/ adjustment works and operations,

Module 01 TT – Innovative Teaching and Learning for Industrial Changes due to Industry 4.0	
Module content	<ul style="list-style-type: none"> • process management (visualization/monitoring/coordination/organization), • operation and monitoring of Cyber Physical Systems (CPS), • operation and control of automated and robotized work-processes of assembly, • guarantee process safety by process monitoring and repair of malfunctions, • innovative didactical approaches to learn and teach within Industry 4.0, • didactically implementing the topic into the vocational training courses; • usage of soft skills in learning and teaching courses related to Industry 4.0, • design of typical learning scenarios, • development of innovative lesson plans related to Industry 4.0., assessment of students' performance in the era of a digitalized world
Course Duration	1 week (40 hours including site visits)
Delivery Methods	<p>Indicate how the course is delivered:</p> <p><input checked="" type="checkbox"/> In-class instruction</p> <p><input type="checkbox"/> Distance education</p> <p><input checked="" type="checkbox"/> Workshop</p> <p><input checked="" type="checkbox"/> Laboratory</p> <p><i>Comments: activity-oriented learning and self-reliant learning have to be in the focus.</i></p>
Didactical comments	<p>The lesson aims to develop a deeper understanding of the 4th Industrial Revolution (Industry 4.0). It does not only help to access the data variety but supports the ability to understand and to apply different data formats and data backup concepts. Focus will be on the relevance of data and on data- and software-based control of plants. Apart from learning how to deal with data in real manufacturing processes in production, the participants will learn about the important role of data- and software-based control of plants in modern production facilities. This complex relationship will be taught with the help of Action Oriented Teaching Approaches (AOTA). A target-oriented promotion of self-reliant learning will help to develop competences that support active learning.</p>
Learning environments	<p>Classroom and Laboratory</p> <ul style="list-style-type: none"> • Classroom: for the theoretical background (flip chart, board, digital media) • Laboratory: for the use of and work with different data formats, software structures and network interlinkage, • Combination of conventional learning with learning in the work-process by using the AOTA approach.
Teaching Methods	<p>Action Oriented Teaching Approaches (AOTA) for self-reliant learning; instructions, lessons, exercises in the laboratory; (small) project-based learning.</p>
Method(s) of Participants Evaluation	<p>Multimedia assisted, computerized-assisted instruction, customize learning device, Motivation Information Application Progress (MIAP), laboratory work.</p> <p>Training pre and post evaluation</p>
Material/Literature	<p>Ustundag, A.; Cevikcan, E. (Eds.) (2018). Industry 4.0: Managing The Digital Transformation. Springer Series in Advanced Manufacturing. 2018. https://doi.org/10.1007/978-3-319-57870-5</p> <p>Wiesner, S., Gorltd, C., Soeken, M., Thoben, K. D., & Drechsler, R. (2014). Requirements Engineering for Cyber-Physical Systems. In Advances in Production Management Systems. Volume 438 of the series IFIP Advances in Information and Communication Technology, 2014, pp. 281–288.</p> <p>J. Longmuß; B. P. Höhne; S. Bräutigam; A. Oberländer; F. Schindler (2017). Agile learning: Bridging the gap between industry and university: A model approach to</p>

Module 01 TT – Innovative Teaching and Learning for Industrial Changes due to Industry 4.0	
Material/Literature	<p>embedded learning and competence development for the future workforce. 44th SEFI Conference, 12–15 September 2016, Tampere, Finland. 2017, pp. 1–8.</p> <p>Kagermann, H., Wahlster, W., J. Helbig, J. (2013). Recommendations for implementing the strategic initiatives Industry 4.0. Final report of the Industry 4.0 Working Group. Frankfurt am Main: acatech – Deutsche Akademie der Technikwissenschaften e. V.</p> <p>Brynjolfsson, E., A. McAfee (2014). The second Machine Age. How the next digital revolution will change our lives. Kulmbach.</p>

5.5 Generating LWA and LWA' descriptions

The generation of the LWA adheres to the above mentioned seven development actions. It is crucial that the generated LWA are closely linked the contents orientation of the module description and that the defined outcomes of the individual LWA can be clearly identified. The LWA are the instrument for working within learning processes in order to reach the designated outcomes.

Module 01 TT: Innovative Teaching and Learning for Industrial Changes due to Industry 4.0

5.5.1 LWA 01 TT

In Module 01 TT the changes in industry and work are at the center of the training. Integrating innovative learning and teaching is highly relevant for Industry 4.0 requirements. In the first group of outcomes, participants will be able to:

- explain the terms digitalization, Industry 4.0, 4th Industrial Revolution, Cyber Physical System (CPS) etc.,
- analyze and interpret the (didactical-methodical) paradigm change happening in industry because of the implementation of Industry 4.0,
- analyze what lean production means and the implications for the organization of manufacturing on the shop floor,
- elaborate the economic goal behind Industry 4.0.

These changes are in the focus of training. Apart from understanding terms, a deeper insight into the paradigm change in industry will be developed and the reasons and implications of this change will be clarified. The main topics which will be covered are:

- terms, introduction to industrial change, change of work, new technology and knowledge,
- impact of Industry 4.0 on changes in the digital work environment at the shop-floor level,
- wider usage of internet in the work-processes of mechatronic systems and other relevant areas.

In addition, using the context of industrial change, implications towards learning-teaching approaches will be discussed. The training will explain and demonstrate selected innovative teaching and learning suitable for the context of Industry 4.0.

The changes which will form the core of the learning processes and learning outcomes will underpin a definition of LWA as follows.

LWA 01 TT: New paradigm: The changes to management and work-processes and consequences for the workforce due to Industry 4.0

This LWA clearly defines a need for dealing with the changes and the impact of Industry 4.0 in TVET and the re-training of the workforce.

5.5.2 LWA 02 TT

Digitalization in industry has a deep impact on the communication between Cyber-Physical Systems and the Internet of Things. This situation has consequences for the organization of work-processes and the requirements of work. These new dimensions are clearly documented in the outcomes in which participants will be able to:

- explain the new level of technical- and software-based communication between the Cyber Physical Systems (CPS) and the Internet or Internet of Things,
- describe the technological and organizational changes of the work-processes in industry.

Due to the application of IoT and CPS, a great number of data are produced and relevant. This is mentioned in the contents of the LWA:

- data availability of sensor, actuator and process data in production systems PPS, MES, SCADA, ERP, SAP,
- structure of technical networks and transfer of Big Data,
- small series and individualised production, executing frequent diverter/adjustment works and operations.

Using the context of man-machine communication, optimization of automation, and consequences for the workforce and security, innovative and relevant learning-teaching approaches will be discussed and demonstrated.

The security of data is an important issue in this type of communication and has to be an important topic during the training. An LWA covering these requirements could be defined as:

LWA 02 TT: Man-machine communication, optimization of automation and the consequences for the workforce and security

This LWA deals with complex and important requirements resulting from the new technologies (man-machine communication and automation) and the reaction of companies in re-organizing their work-processes for the organization of more efficiency. These developments have deep consequences for the change in the quality of work. Based on this, training in the implication of technology (Cyber Physical Sys-

tems, Internet), software, work organization and quality requirements for the workforce have to be discussed in detail. Data security is a further issue which has to be considered because of its relevance for all fields.

5.5.3 LWA 03 TT

This module aims at deepening the dimensions of technology and software. Without an understanding of the work of automated systems, the role of different types of formats, data safety and software operation, it is not possible to shape teaching and learning processes. On completion, participants will be able to:

- demonstrate how to use IT instruments when working with automated systems and be able to make use of them within the education and training processes,
- demonstrate how to work with the different types of data formats and data safety systems and ensure safety,
- solve various issues dealing with the content of embedded systems, including their operating systems.
- Give orientation on the field of relevance and requirements.

In this case the specific implications and interrelations of technology software solutions, repair of malfunctions and automation have to be in the focus of training. The main contents of this issue are:

- handling data: saving data, cloud computing, data security, data mining,
- process management (visualization/monitoring/coordination/organization),
- operation and monitoring of Cyber Physical Systems (CPS),
- operation and control of automated and robotized work-processes of assembly,
- guarantee process safety by process monitoring and repair of malfunctions.

Using the context of *changing in process management, optimization of automation and guarantee of process and data safety*, innovative and relevant learning-teaching approaches will be discussed and demonstrated.

The definition of an LWA might be:

LWA 03 TT: Process management, optimization of automation and guarantee of process and data safety

A requirement for the development of competences is to use different monitoring systems and visualization for the learning and teaching processes along with embedded systems including their operation and to clarify the role of different formats and their implications. The interconnection of different types of technologies for the optimization of automation has to be dealt with in another field of the learning process.

5.5.4 LWA 04 TT

LWA 01, 02 to 03 focus on technical and organizational changes and the optimization of work-processes in the context of digitalization. LWA 04 is oriented to identifying approaches and models to teach the requirements related to digitalization. Up to now,

no specific approach has been developed for teaching in the field of digitalization. Due to the dynamics of changes in the world of work, it is deemed necessary to enable students to work freely, self-reliantly and in a problem-oriented way. This means that teaching and learning processes must be planned that rely on a variety of methods and self-reliant learning which shall be adequate for digitalization/Industry 4.00. This will be underpinned by the expected learning outcomes, where participants will be able to:

- elaborate and demonstrate how to use different didactical approaches that enable students and apprentices to work freely, self-reliantly and be problem-oriented,
- facilitate autonomous development of specific technical skills needed for handling of the different media measures, instruments, that in most cases are learned through experience,
- make use of soft skills needed for the digitalized world, especially the competences of networking and communication,
- have the capability to deal with stress tolerance, flexibility, the knowledge of the industry, keeping updated, language skills,
- plan lessons by using innovative teaching methods/technology such as simulation, role-playing, portfolio development and problem-based learning (PBL) etc.,
- assess students' performance in the era of a digitalized world.

In order to meet the request of learning outcomes, it is necessary to include learning phases in real laboratories or enterprises. During these phases, experience with real requirements regarding the use of high-tech plants and different forms of work could be acquired. This may be achieved with the help of planning and implementation of complex learning situations. Concrete contents for these challenges are:

- didactical approaches to learn and teach within Industry 4.0,
- didactically implementing the topic into the vocational training courses,
- design of typical learning scenarios.

Based on this, an LWA could be defined as follows:

LWA 04: Planning of teaching lessons and use of multifunctional didactical approaches for a deeper understanding of digital-based modern industry

Based on the respective expertise of the participants in this training measure, it has to be verified whether it would be possible to place the didactical planning as a first step of the training and to plan the entire module contents in the form of a project which could then be implemented step by step.

The generated four LWAs are the backbone of the learning and teaching process in the sense of a detailed syllabus. The details of the LWAs are described and the learning outcomes are defined in the outline.

5.5.5 Summary

So far, the generation of LWA ensures the transfer of module contents and learning outcomes in a way that facilitates an open planning of learning. It is thus guaranteed that the transfer process includes methodological variety which not only helps to support methodological skills in the learner but, in addition, promotes the development of self-reliant and flexible acting due to the use of learner-centered approaches. The term “learning theories” (cf. Chapter 4) has already been discussed in more detail.

5.6 Outline of Learn- and Work Assignments

The definition of the LWA is the foundation for innovative learning and teaching. Planners of learning processes, however, expect further hints for a successful implementation of LWA. The core priorities are named in the forms LWA 01 TT to LWA 04 TT.

Description LWA 01 TT to LWA 04 TT

- Four LWA were developed for Module 1. They are described in more detail in an identical form for all LWA.
- Apart from the naming of the respective module, the relation to the relevant module is established and the time frame is determined.
- Another factor is the determination of the planned group size working on the implementation of the LWA.
- The description of the contents of LWA is important as it underlines which priority contents of the module will be used for the respective LWA. A decision will be made based on the definition of the LWA.
- Another important element is the description of the dimension of competences to be supported by learning. They are:
 - professional competences (subject related and highly relevant for skills in TVET workforce),
 - methodological competence (different ways of working and problem solving, work organization and use of tools, respect and use of rules, adhering to ecological requirements etc.),
 - personal and social competences (cooperation, communication in all dimensions, deeper view on the importance of communication, focus on customers and others).
- The entry prerequisites determine which target group will be offered preference to participate in further training on the module and on the LWA.
- The methods of delivery provide important hints to the questions referring to methods which should be applied during the training. Apart from a close interrelationship between theory and practice, methods and forms of learning are given priority in order to promote self-reliance and acting competence. It is important to note that based on Module 1 LWA 04 TT students can explicitly work on “planning of teaching lessons and use of multi-functional didactical approaches of dig-

itally based/modern industry”. This means that this LWA aims to promote the innovative competences of the teaching staff.

- The priority “media and resources” accompanies the “methods of delivery”. The real spectrum of usable media is extensive. Only the most important media are mentioned.
- The priority “assessment methods” round out the given hints. It is mainly about providing learners with the opportunity to give feedback regarding the implementation of learning contents.

The accompanying descriptions for all four LWAs are described below. They should first and foremost give hints to the teaching staff for a successful implementation.

With regard to Modules 2 and 3

- the module descriptions,
- the generation of LWAs and
- the framework of didactical implementation

can be found in the Annex. The implementation principles correspond with those described here. A repetition is not deemed necessary.

LWA 01 TT: New paradigm: the changes of management- and work- processes and consequences for the workforce due to Industry 4.0

1.	LWA	LWA 01 TT: New paradigm: the changes of management- and work-processes and consequences for the workforce due to Industry 4.0
2.	Assigned to Core Work-process	Module 01 TT: Innovative Teaching and Learning for Industrial Changes due to Industry 4.0
3.	Time frame	8 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>The 4th Industrial Revolution (Industry 4.0) has impacts on all our activities in different areas. Disruption is the term used in many cases to describe the changes. This situation requires a deeper understanding of the paradigm change going on in industry and the identification of consequences for our lives and skilled work.</p> <p>The impact of Industry 4.0 is manifold. All the working areas in smart industries are confronted with new working opportunities offered by using Cyber Physical Systems, their new communication structure, the change of work-processes and work organization. In this LWA, the changes and implications in the industry, the target of process optimization by using lean production concepts and Cyber Physical Systems are in the focus of the teaching and learning processes.</p> <p>Commonly used terms such as digitalization, Industry 4.0, smart industry, disruption, paradigm changes, CPS etc. will be clarified.</p>

6.	Widening of competence¹⁶ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Explain the terms digitalization, Industry 4.0, 4th Industrial Revolution, Cyber Physical System (CPS), disruption, etc.,</p> <ul style="list-style-type: none"> • basic knowledge of the terms and their definitions, • importance of the different terms in relation to the changes in industry and production. <p>Analyze and explain the paradigm change happening because of the implementation of Industry 4.0, and understand the economic goal behind Industry 4.0,</p> <ul style="list-style-type: none"> • awareness and understanding of deep changes in technology and use of technology, • analyze the changes of work organization for optimizing efficiency and different use of technology, • state consequences of the paradigm change on economy, ecology, skill needs, employment and workforce. <p>Analyze what lean production means and what the implications are for the organization of manufacturing and other relevant areas, e. g. agriculture and services industry,</p> <ul style="list-style-type: none"> • deeper knowledge of different conceptions of lean production, • ability in using different organizational concepts, • differences about the impact of different organizational concepts and how to make use of them (esp. "lean concepts") for automation.
7.	Entry prerequisites	<ul style="list-style-type: none"> • Basics in teaching in TVET, • experience working in TVET/industries, • at least 2 years of working experience in vocational education and training or at least 2 years of relevant industrial experience, • at least 3 years before retirement, unless strong reason given for participating.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainers act as facilitators, • promote sharing of self-learning phases (information, planning, decision making, execution, controlling and evaluation), • introduce group work, • carry out teaching & learning of LWAs in a special classroom for combined theory and practice arrange visits to companies and laboratories (incl. exercises), • use real materials and tools.
9.	Media and resources	<p>Apart from the traditional media (PC, projector, flip chart etc.) the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialized textbooks for digitalization, • online learning tools or management systems.
10.	Assessment methods	<ul style="list-style-type: none"> • Systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.

¹⁶ The types of "competence" will be described in a paper "explanation of terms".

LWA 02 TT: Man-machine communication, optimization of automation and consequences for the workforce and security

1.	LWA	LWA 02 TT: Man-machine communication, optimization of automation and consequences for the workforce and security
2.	Assigned to Core Work-Process	Module 01 TT: Innovative Teaching and Learning for Industrial Changes
3.	Time frame	10 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>The 4th Industrial Revolution (Industry 4.0) has an impact on all our activities in different areas. With a target of higher efficiency in the different processes of service, production, banking business etc., companies and branches reorganize their work and this has a deep impact on skills needed.</p> <p>All the working areas in a smart factory and other areas are confronted with new working opportunities offered by the use of Cyber Physical Systems and the changes in work-processes and work organization. Dealing with a number of different data formats, high number of data, cloud computing, data safety and data mining means that new dimensions of work on the shop-floor are available for everybody. Data safety becomes one of the most important issues for the industry. Based on the new communication of Cyber Physical Systems and internet with the help of software, the relevance of the work-processes and automation has to be clarified including the consequences for work requirements and skilled work.</p>
6.	Widening of competence¹⁷ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Are able to understand the new level of technical- and software-based communication – based on different data formats – between the Cyber Physical Systems and the internet or internet of things,</p> <ul style="list-style-type: none"> • Knowledge of the function of Cyber Physical System (CPS), • can analyze the structure of the communication between CPS and internet based on different data formats, • can explain the role of the software and the monitoring process of the software in the communication between CPS and internet, • able to shape the communication process between CPS and internet and reorganize the structure if needed, • explain the structure of the software in use in the context of automation. <p>Have developed the ability to understand the technological and organizational changes of the work-processes in manufacturing and other relevant areas e. g. agriculture and services industry,</p> <p>have deep insight into the interrelation of changes of work organization, use of technology and the implications for quality,</p> <p>show that quality of work depends on the type of work organization and workforce,</p> <p>able to shape work organization in a human friendly way,</p> <p>able to analyze the skill needs related to the organization of work-processes.</p>

¹⁷ The types of “competence” will be described in a paper “explanation of terms”.

7.	Entry prerequisites	Master the basics in teaching in TVET, have experience working in TVET/industries, at least 2 years of working experience in vocational education and training or at least 2 years of relevant industrial experience, at least 3 years before retirement, unless strong reason given for participating.
8.	Method of delivery	Trainers act as a facilitator, promote sharing of self-learning phases (information, planning, decision making, execution, controlling and evaluation), introduce group work, carry out teaching & learning of LWAs in a combined (theory/practice) special classroom, conduct visits to companies and laboratories (incl. exercises), use of real materials and tools.
9.	Media and resources	Apart from the traditional media (PC, projector, flip chart etc.) the following additional media are required: safety instruction data sheets provided by the trainer, specialized textbooks on digitalization, online learning tools or management systems.
10.	Assessment methods	Systematic and precise documentation of the teaching and learning process, assessment/evaluation of the teaching and learning approach and process, each participant documents the work tasks in his/her own portfolio.

LWA 03 TT: Process management, optimization of automation and guarantee of process and data safety

1.	LWA	LWA 03 TT: Process management, optimization of automation and guarantee of process and data safety
2.	Assigned to Core Work-process	Module 01 TT: Innovative Teaching and Learning for Industrial Changes
3.	Time frame	12 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	LWA 03 TT will focus on technological, safety and software dimensions. A deep understanding of the monitoring role of the software has to be developed. Training on working with different types of data must be given as well as safety in using data in shaping processes. The very close relations between software, data, technology, internet and their implications have to be demonstrated. Different shaping approaches will be offered for the design of manufacturing units with the direction of automation and securing safety issues. The process of competence development will be linked to the context of Industry 4.0.

6.	Widening of competence¹⁸ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Capability to use IT competences in the work with automated systems and ability to make use of it within the education and training processes,</p> <ul style="list-style-type: none"> • explain the function of IT components within the automated technology, • analyze the correct function of IT components within automated machinery, • ensure the function of automated systems, • organize automation processes, • take over responsibility for quality-based work-processes. <p>Able to use and work with the different types of data formats and data safety systems,</p> <ul style="list-style-type: none"> • explain the relevance of different data formats and their use, • ensure safe work with different formats, • use of instruments to ensure data safety, • select which type of format is used for the different machines and why, • take over responsibility for the correct use of different data formats within work-processes. <p>Develop competences related to dealing with the content of embedded systems, including their operating systems,</p> <ul style="list-style-type: none"> • explain the role and function of embedded systems, • ensure the function of embedded systems (repair them), • identify malfunctions of embedded systems, • show how to ensure high-quality production.
7.	Entry prerequisites	<ul style="list-style-type: none"> • Master the basics in teaching in TVET, • at least 2 years of working experience in vocational education and training or at least 2 years of relevant industrial experience. • at least 3 years before retirement, unless strong reasons given for participating.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainers act as a facilitator, • promote sharing of self-learning phases, (information, planning, decision making, execution, controlling and evaluation), • introduce group work, • carry out teaching & learning of LWA in a combined (theory/practice) special classroom, • conduct visits to companies and laboratories (incl. exercises), • use of real materials and tools.
9.	Media	<p>Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialized textbooks for digitalization, • online learning tools or management systems.
10.	Assessment methods	<ul style="list-style-type: none"> • systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.

¹⁸ The types of "competence" will be described in a paper "explanation of terms".

LWA 04 TT: Planning of teaching lessons and use of multifunctional didactical approaches for deepening understanding of digital-based/modern industry

1.	LWA	LWA 04 TT: Planning of lessons and use of multifunctional didactical approaches for deepening understanding of digital-based/modern industry
2.	Assigned to Core Work-process	Module 01 TT: Innovative Teaching and Learning for Industrial Change
3.	Time frame	10 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>Changes in the world of work because of the 4th Industrial Revolution (Industry 4.0) require continuous teacher training and the use of sophisticated didactical approaches. In this module, different didactical approaches will be used for planning lessons to support problem-based learning and self-reliant learning processes. Social forms of learning such as role-playing, teamwork, portfolio work and others will be used.</p> <p>Based on a target to create a deeper understanding of the impact of digitalization on skilled work and to be able to operate automated systems, training will be designed to use sophisticated didactical approaches for developing competences of teachers and trainers so that they are able to train their students in this required field. Participants will also be guided to make use of modern digital equipment and simulators, of different media, data bases and other equipment. Didactical ways of using such instruments in different situations of learning will be clarified.</p>
6.	Widening of competence¹⁹ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Plan and deliver lessons by using innovative teaching methods/technology such as simulation, role-playing, portfolio development and problem-based learning (PBL) etc.,</p> <p>Have the knowledge to make use of different didactical approaches that enable students and apprentices to work freely, self-reliantly and be problem-oriented,</p> <ul style="list-style-type: none"> • lessons using didactical approaches which allow innovative teaching and learning, • deliver lessons that make use of digital equipment, digital machinery, simulation and others, • plan and deliver lessons which support problem-based and self-reliant learning, <p>Able to facilitate autonomous development of specific competences needed</p> <ul style="list-style-type: none"> • facilitate an autonomous process of learning to develop specific technical skills needed for handling the different media measures, instruments, laboratory equipment etc., • use of experience-based learning, • comply with learning situations that allow the development of a deep understanding of the function of digitalized technology,

19 The types of "competence" will be described in a paper "explanation of terms".

6.	Widening of competence Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Able to use of soft skills needed for digitalized world, especially the competences of networking and communication,</p> <ul style="list-style-type: none"> • compose teamwork, work in focus groups, work with different social approaches (fishbowl etc.), • apply different approaches of problem-solving. <p>Able to deal with stress tolerance, flexibility, the absolute knowledge of the industry, keeping updated, language skills,</p> <ul style="list-style-type: none"> • deep understanding of the necessity of long-term perspectives for quality-based work, • visit companies to discuss flexibility, work pressure, types of work organization and consequences, • document and present findings of quality and human-oriented work. <p>Able to assess students' performance in the era of a digitalized world.</p>
7.	Entry prerequisites	<ul style="list-style-type: none"> • Master the basics in teaching in TVET, • at least 2 years of working experience in vocational education and training or at least 2 years of relevant industrial experience, • at least 3 years before retirement, unless strong reason given for participating. <p>Facilitator can refer to SEA-VET.net under GOOD PRACTICES and UNESCO UNEVOC under PROMISING PRACTICES.</p>
8.	Method of delivery	<ul style="list-style-type: none"> • Trainers act as a facilitator, • promote sharing of self-learning phases (information, planning, decision making, execution, controlling and evaluation), • introduce group work, • carry out teaching & learning of LWAs in a combined (theory/practice) special classroom, • conduct visits to companies and laboratories (incl. exercises), • use of real materials and tools.
9.	Media and resources	<p>Apart from the traditional media (PC, projector, flip chart etc.) the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialized textbooks for digitalization, • online learning tools or management systems.
10.	Assessment methods	<ul style="list-style-type: none"> • systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.

6 Implementation Process of the Modules and In-Service Training

The implementation process covered three steps:

Step 1: Identification of required training

Step 1 encompassed first and foremost the identification process of the relevant needs. This was achieved with the help of carefully selected experts from the ASEAN countries and included the analyses of available surveys on industrial development in the respective regions. After a first workshop, a roughly sketched module based on a training concept for in-service training was finally available, resting on two pillars:

- requirements of Industry 4.0 and
- innovative teaching and learning.

In a next step of discussion, feedback based on a questionnaire was initiated. After this, three modules (Modules 1–3) with a clear relation to Industry 4.0 were specified as well as two additional modules dealing with:

- Quality assurance and Quality Development, and
- Industry and linkages with vocational institutes.

These two modules underline that central developments such as digitalization/Industry 4.0/Quality Assurance and Quality Development as well as the cooperation of learning environments represent the key elements of a functioning vocational education.

The concept featuring the five modules was discussed and further improved during another expert workshop. The aim was to implement the concept within the framework of an in-service training and to train multipliers. The choice of the experts always took into consideration that:

- they are able to represent training centers,
- they are able to represent the position and the interests of their governments, and
- the needs of industry are given adequate consideration.

Step 2: Development of an innovative training concept

After the modularized concept was developed, the core question was to clarify how the transfer into a training process should be realized. The expert group working on this question at the time agreed that the specifications given in the module description were not sufficient. The group rather imagined a theoretical concept which supports innovative learning, above all promoting self-reliance. At the same time the competence development oriented to Industry 4.0 could serve as a red thread. However, the learning outcomes of the modules had already defined the contents framework for the

core issues of Industry 4.0 (based on chapters 2 and 3). What was left was the selection of adequate learning and teaching theories and methods which could be used for these demanding contents. An in-depth discussion of this issue is ongoing, above all in chapters 4 and 5. The concept of the LWA is presented there.

The LWA are the pivotal point for the shaping of learning and teaching. A variety of methods and media are applied. According to the respective targets, self-reliance, teacher lectures, problem-solving and other kinds of learning can be placed at the center of learning processes. LWA in combination with various other learning methods have the advantage that they are suitable for a contents-related, professional and subject related development of competences as well as the development of methodical competences, social and personal competences.

Another advantage of LWA is the fact that contents could be modified and exchanged in the face of changed requirements without changing the orientation or the demands for the training. Given the orientation of the contents to Industry 4.0, it is most likely that this will be necessary from case to case.

The LWAs generated from the modules have already been evaluated and authorized by the above-mentioned expert group. However, the changes in the industrial environment are progressing very quickly leading to the need of a modification of LWA.

Step 3: Selection of TVET training institutions and organization of the in-service training.

Another important task was to identify training institutions that are able to offer Industry 4.0 related training in laboratories for in-service training. For this training it was necessary to ensure the availability of both the necessary equipment and trainers who would be able to offer and to successfully conduct the respective training course. These two locations were integrated into the training. The theory-oriented training required the selection of lecturers for the in-service training who should be able to identify these complex contents. Finally, a teacher team with participants from different countries was installed to cope with this task. The teacher crew faced great difficulties making themselves familiar with the issues. The greatest challenge was to impart the new contents and requirements resulting from Industry 4.0 with the help of teaching aids which support learner centring and self-reliance.

The following “success factors” (Table 9) were at the center of the entire project on the development of the innovative approach of teaching and learning as well as the shaping of the modules. Both the expert committee and the experts for development supervised this process.

Table 9: Success factors

Step	Activity
1	Analysis of the requirements of industry and partners
2	Analysis of the possible institutional framework for innovative training
3	Set-up of an expert committee for the shaping of the training programme
4	Identification of quality-oriented partners
5	Creation of participatory processes of development with responsible organizations
6	Encouragement of utilization of outputs at the regional and national level
7	Systematic follow-up on impact.

The close orientation on these seven steps during the planning and the conduct of the project ensured a high quality. The results were rated very positively by all stakeholders.

7 Conclusion

Based on the presented concept, the objective of in-service training, e. g. the qualification of multipliers for innovative teaching methods and Industry 4.0, was reached. The pilot phase was successfully completed with the help of the RECOTVET Programme (Regional Cooperation Programme to Improve the Quality and Labor Market Orientation in TVET). The in-service training took place in close cooperation with SEAMEO VOCTECH. Around 200 multipliers from TVET institutions of the 10 ASEAN countries and Timor-Leste were trained.

Strategic technical topics of Industry 4.0, innovative learning and teaching issues for Quality Development were in the centre of interest. Modules 1 and 2 concentrated on the subject related competences of Industry 4.0 whereas Module 3 dealt with work-process-based curriculum development. The special challenge of Module 3 was the development of curricula with an orientation to Industry 4.0. Module 4 dealt with the new key issues for quality development. Thus, the “forgotten group of students” was declared the target group for Quality Development. Progress in quality may be expected along with an improved quality of learning and teaching.

The participants of the training were carefully selected. Those working for Modules 1 and 2 and participating in company visits and laboratory training sessions had to present a technically oriented prequalification (e. g. Bachelor of Engineering or comparable certificates). Experience as a teacher was also demanded. As for Modules 3 and 4, no technical or engineering-scientific prerequisites were required. However, the participants were required to have experience as a teacher or in curriculum development and/or quality assurance.

Another important prerequisite for the participation was the pledge of all multipliers to further qualify persons in their own institutions after having passed their further training. Up to the end of the training measure, the participants had to work out an implementation concept for their planned training course and to present it to the peer. The subsequent discussion contributed to the optimization of the respective multiplier concepts.

The Sustainable Development Goals (SDGs) indicated the importance of Quality Assurance (QA) in TVET provision. Accordingly, by 2030 access for all men and women to quality VET should be ensured. By its nature TVET is designed to prepare a quality labor force, to supply competent workers to the labor market and to prepare people for their role in the society. Given its role, good quality TVET will significantly contribute to economic growth and stability of a country. For this reason, working on QA in TVET becomes imperative. This is the overall target of the training of multipliers.

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Attachment

Description of Modules 02 and LWAs

Module 02 PTT – Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0	
Training Module Title	Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0
Responsible Person	NN
Target group	TVET teachers (teachers/instructors of all levels, master trainers, ToT trainees)
Module Description	<p>The capacity of TVET teachers to successfully manage and implement the overall working processes needs to be continually improved. Today, the 4th Industrial Revolution (Industry 4.0) is initiating changes all over different business sectors and in private life. In the literature the term “disruption” is widely used for the changes. All the working areas in a smart factory have to deal with the new working opportunities offered by the use of Cyber Physical Systems and the change of work-processes and work organization.</p> <p>This module is focused on the continuous professional development of the TVET teachers' capabilities that play a pivotal role in:</p> <ul style="list-style-type: none"> • updating knowledge and pedagogical skills (based on different and new technologies, change of work, know-how, materials etc.), • upgrading specific technical competences, • upgrading teaching skills in the context of complex technology and the work-process relation, • enhancing industrial experience. <p>Industry 4.0 is integrating a variety of different technologies into a complete system. The most important features of this system are the intelligence of the individual components and the way that these components network with smart factories. This will be the main requirement for a teaching process and methods are needed for the best way to teach it.</p>
Module Prerequisites	<p>At least 3 years of working experience in technical & vocational education and training or industry.</p> <p>Having a background in industrial automation with specific technical knowledge and skills as stipulated in the Learn- and Work Assignment requirements.</p>
Learning outcomes	<p>The participants will be able to:</p> <ul style="list-style-type: none"> • describe the development of industry 3.0 to 4.0, • recognize the development of the production and business processes of industry and the role of software monitoring, • explain the new level of software-based communication between the Cyber Physical Systems and the internet or internet of things, • explain the flow of information in digitalized technology • analyze information from intelligent sensors and components, • program the operation of a station using Programmable Logic Controllers (PLC) and Human-Machine Interface (HMI), • monitor the operation using supervisory control and data acquisition (SCADA), • evaluate the process data for optimizing the system efficiency,

Module 02 PTT – Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0	
Learning outcomes	<ul style="list-style-type: none"> • identify the design structure of Industry 4.0 factories: sensors/actuators, process modules, cells, networking, process and operation command level, Manufacturing Execution Systems (MES), • explain the flow of material: using Radio Frequency Identification (RFID) and Near Field Communication (NFC) to identify products that need to be manufactured, • apply “Manufacturing Execution Systems (MES) simulation”: creating, managing, controlling, and visualizing orders on the value-adding process level, • explain the customization processes of product, • introduce modern didactical approaches within teaching of Industry 4.0 to enable students and trainees to work freely, self-reliant learning and be problem-oriented, • arrange the use of modern teaching methods, • plan learning units in the context of Industry 4.0, • carry out practical exercises in a lab. <p>During this training course, participants will learn about the interplay between components within a complete production process using a laboratory. At the same time, they will come up with didactical concepts to integrate the topic of Industry 4.0 into a vocational training course.</p>
Module content	<p>Major topics that will be covered during the course</p> <ul style="list-style-type: none"> • interface of 3.0 & 4.0 and the differences and why the need for 4.0, • impact of Industry 4.0 in changes of work on the shop-floor level, • wider usage of Internet in the production and business processes of industry production, • new level of technical and software-based communication between the Cyber Physical Systems and the internet or internet of things, <ul style="list-style-type: none"> – the importance of software, – the digital communication between different systems, – digital-based communication process between the different instruments and machinery and malfunctions, – introduction to Enterprise Resource Planning (ERP), • process management (visualization/monitoring/coordination/organization), • efficiency: usage monitoring, recording consumption, localizing and identifying energy losses, drawing conclusions from increased energy consumption about component wear and behavior in the event of failure, • design structure of Industry 4.0 factories: sensors/actuators, process modules, cells, networking, process and operation command level, MES, • RFID and NFC to identify products that need to be manufactured, • “Manufacturing Execution Systems (MES) simulation”: creating, managing, controlling, and visualizing orders on the value-adding process level, • customization and individualization of the products, • new approaches to the planning and organization of TVET training, • preparing training and education with the help of projects or self-reliant learning in the context of Industry 4.0 topics, • didactical approaches to learn and teach within Industry 4.0.
Course Duration	8 days (48 hours)
Delivery Methods	<p>Indicate how the course is delivered:</p> <p><input checked="" type="checkbox"/> In-class instruction</p> <p><input type="checkbox"/> Distance education</p> <p><input checked="" type="checkbox"/> Workshop</p> <p><input checked="" type="checkbox"/> Laboratory</p> <p><i>Comments: Company visit and visit to a high-tech Lab at a TVET center</i></p>

Module 02 PTT – Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0	
Didactical comments	In the seminar, a deeper understanding of the interrelation of the components of Industry 4.0 units and plants will be developed. Participants will be able to identify the components and/or technology units used and understand their functions, effects, and interplay. They will know how to make use of these technologies in vocational training courses, prepare initial areas of application for their courses, and plan an example learning unit or project.
Learning environments	Classroom and Laboratory <ul style="list-style-type: none"> Classroom: for the theoretical background (flip chart, board, digital media) Company/Laboratory: level and quality of requirements.
Teaching Methods	Seminar mode and visits, Laboratory.
Method(s) of Student Evaluation	Simulation, Multimedia assisted, computerized assisted instruction. Training pre- and post-evaluation.
Material/Literature	<p>Ustundag, A.; Cevikcan, E. (Eds.) (2018). <i>Industry 4.0: Managing The Digital Transformation</i>. Springer Series in Advanced Manufacturing. 2018. https://doi.org/10.1007/978-3-319-57870-5</p> <p>Wiesner, S., Gorldt, C., Soeken, M., Thoben, K. D., & Drechsler, R. (2014). Requirements Engineering for Cyber-Physical Systems. In <i>Advances in Production Management Systems</i>. Volume 438 of the series IFIP Advances in Information and Communication Technology, 2014, pp. 281–288.</p> <p>J. Longmuß; B. P. Höhne; S. Bräutigam; A. Oberländer; F. Schindler (2017). Agile learning: Bridging the gap between industry and university: A model approach to embedded learning and competence development for the future workforce. 44th SEFI Conference, 12–15 September 2016, Tampere, Finland. 2017, pp. 1–8.</p> <p>Kagermann, H., Wahlster, W., J. Helbig, J. (2013). Recommendations for implementing the strategic initiatives Industry 4.0. Final report of the Industry 4.0 Working Group. Frankfurt am Main: acatech – Deutsche Akademie der Technikwissenschaften e. V.</p> <p>Brynjolfsson, E., A. McAfee (2014). <i>The second Machine Age. How the next digital revolution will change our lives</i>. Kulmbach.</p>

Module 02 PTT: Professional Development Training for TVET Teachers in Industry 4.0

Generating of LWA

LWA 01

In this LWA, a deeper understanding of the consequences of the implementation of Industry 4.0 will be created. Above all, the role of the software will dominate the teaching and learning process in order to reach learning outcomes. Where participants will be able to:

- describe the development of industry 3.0 to 4.0
- recognize the development of the production and business processes of industry and the role of software monitoring,
- explain the new level of software-based communication between the Cyber Physical Systems and the Internet or Internet of Things,

The contents of LWA 01 are:

- interface of 3.0 & 4.0 and the differences and why the need for Industry 4.0
- impact of Industry 4.0 on changes of work at the shop-floor level,
- wider usage of internet in the production and business processes of industry production,
- new level of technical and software-based communication between the Cyber Physical Systems and the Internet or Internet of Things.
- the importance of software,
- the digital communication between different systems,
- digital-based communication process between the different instruments and machinery and malfunctions,
- introduction to Enterprise Resource Planning (ERP).

These contents underpin that a new level of use of software and communication with the internet will be the main field of discussion. In particular, the consequences for requirements at the shop-floor level and the changes in the work-processes will be clarified. This also includes dealing with sensors, actors, impact of digitalized signals and others. The definition of the LWA might be:

LWA 01 PTT: The role of the software within the communication process of machinery and the internet.

The impact on the change of work-processes and changed work- and technology-related requirements can be discussed in detail here.

LWA 02 PTT

LWA 02 has to be understood as a continuation of LWA 01. The data collected by the sensors and programming of PLCs to monitor processes are the core of these tasks. This requires a deep understanding of the process and function of technology and the capability to monitor and optimize work-processes. It will be a learning outcome that the participants will be able to:

- explain the flow of information in the digitalized technology,
- analyze information from intelligent sensors and components,
- program the operation of station using PLCs and HMI,
- monitor the operation using Supervisory Control and Data Acquisition (SCADA),
- evaluate the process data for optimizing the system efficiency.

These outcomes underpin the close interrelation between

- technology,
- software and
- work-processes.

Apart from technology, visualization and monitoring the process, the module contents must also consider energy saving measures:

- process management (visualization/monitoring/coordination/organization),
- efficiency: usage monitoring, recording consumption, localizing and identifying energy losses, drawing conclusions from increased energy consumption on component wear and behavior in the event of failure.

The module contents demonstrate the complex requirements including the identification of faults. A possible LWA based on the outcomes and contents could be:

LWA 02 PTT: Monitoring and programming Industry 4.0 production using digitalized technology

LWA 02 PTT must also be taught in real production facilities and laboratories. This is needed to ensure a deeper insight into the complexity of technology and process organization.

LWA 03 PTT

This LWA deals with the details of a manufacturing process and mainly focuses on the technological components and processes. As the learning outcome, participants must be able to:

- identify the design structure of Industry 4.0 factories: sensors/actuators, process modules, cells, networking, process and operation command level, Manufacturing Execution Systems (MES),
- explain the flow of material: using RFID and NFC to identify products that need to be manufactured,
- apply MES simulation: creating, managing, controlling and visualizing orders on the value-adding process level,
- explain the customization processes of product.

The requirement to understand the structure of Industry 4.0 factories means to be able to understand the technical networks, their software-monitored function, their work-processes and real operation. The function of RFID and other specific sensors and actors must be understood and applied in the correct way. The use of “Manufacturing Execution Systems” (MES) and visualizing processes are further main topics which have to play a central role in the teaching and learning processes. With regard to these expected outcomes, training in real manufacturing units or laboratories using the same equipment must be carried out. The module content is described as follows:

- design structure of Industry 4.0 factories: sensors/actuators, process modules, cells, networking, process and operation command level, MES,
- RFID and NFC to identify products that need to be manufactured,
- “Manufacturing Execution Systems (MES)”: creating, managing, controlling, and visualizing orders on the value-adding process level,
- customization and individualization of the products.

Based on this description, the LWA will be generated as follows:

LWA 03 PTT: Optimizing industry processes based on Industry 4.0

This underpins the need to put a whole manufacturing process – including its work organization and the applied technology – at the center of the teaching and learning process.

LWA 04 PTT

LWA 01, 02 to 03 focus on technical and organizational changes and the optimization of production and production-related work-processes in the context of digitalization. LWA 04 is oriented towards identifying approaches and models to teach the requirements related to digitalization. Up to now, no specific approach has been developed for teaching in the field of digitalization. Due to the dynamics of changes in the world of work, it is deemed necessary to enable students to work freely, self-reliantly and in a problem-oriented way. This means that teaching and learning processes must be planned which are based on corresponding approaches which are thus adequate for digitalization/Industry 4. This will be underpinned by the expected learning outcomes, where participants will be able to:

- introduce modern didactical approaches within teaching of Industry 4.0 to enable students and trainees to work freely, self-reliantly and be problem-oriented,
- arrange the use of modern teaching methods,
- apply soft skills training needed for the digitalized world, especially the competences of networking and communication, flexibility, keeping updated with languages,
- plan learning units in the context of Industry 4.0,
- carry out practical exercises in a lab.

In order to meet the demands of learning outcomes, it is necessary to include learning phases in real laboratories or enterprises. During these phases, experience with real requirements regarding the use of high-tech plants and different forms of work could be acquired. This may be achieved with the help of planning and implementation of complex learning situations. Concrete contents for these challenges are:

- new approaches to the planning and organization of TVET training,
- training and education with the help of projects or self-reliant learning in the context of Industry 4.0 topics,
- didactical approaches to learn and teach within Industry 4.0.

Based on this, the LWA could be defined as follows:

LWA 04 PTT: Planning of teaching lessons and use of multifunctional didactical approaches for a deeper understanding of digital-based modern production

Based on the respective expertise of the participants in this training measure, verification must be undertaken on whether it would be possible to place the didactical plan-

ning as a first step of the training and to plan the entire module contents in the form of a project which could then be implemented step by step.

LWA 01 PTT: The role of software within the communication process of machinery and internet

1.	LWA	LWA 01 PTT: The role of software within the communication process of machinery and internet
2.	Assigned to Core Work-process	Module 02 PTT: Professional Development Training for TVET teachers on Industry 4.0
3.	Time frame	6 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>The 4th Industrial Revolution requires the capacity of TVET teachers in successfully managing and implementing innovative training programmes to be continually improved. Industry 4.0 initiates changes all over different business sectors and in private life. TVET systems and centers have to provide an answer to these developments.</p> <p>All the working areas in a smart factory are confronted with the new working opportunities offered by using Cyber Physical Systems and the change of work-processes and work organization. In this LWA, competences of TVET teachers will be further developed in the areas of</p> <ul style="list-style-type: none"> • different and new technologies, changes of work, know-how, materials etc. and • communication between cyber physical software, internet and machinery. <p>This should be understood as an upgrading process of specific technical competences which includes some insight into the needs of industry.</p>
6.	Widening of competence ²⁰ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Describe the development of industry 3.0 to 4.0,</p> <p>Recognize the development of the production and business processes of industry and the role of software monitoring,</p> <ul style="list-style-type: none"> • deeper understanding of the changes in the industry and their TVET activities, • conclusions for innovative training programmes in TVET. <p>Explain the new level of software-based communication between the Cyber Physical Systems and the internet or internet of things,</p> <ul style="list-style-type: none"> • deeper insight into the importance of software, • knowledge of the digital communication between different systems, • capability to read and to analyze the digital-based communication process between the different instruments and machinery, • ability to identify malfunctions.
7.	Entry prerequisites	<ul style="list-style-type: none"> • background in industrial automation, • approx. 3 years of working experience in vocational education and training or industry, • basics in teaching in TVET, • experience in working in TVET/industries, • capable of innovative teaching and learning,

20 The types of "competence" will be described in a paper "explanation of terms".

7.	Entry prerequisites	<ul style="list-style-type: none"> • ability to work in innovative teams, • quality conscientiousness • ability in documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • trainer is acting as a <i>facilitator</i> • <i>high share of self-learning phases (information, planning, decision making, execution, controlling and evaluation),</i> • <i>group work and other social forms should be introduced,</i> • <i>teaching & learning with LWA will be carried out in a combined (theory/practice) special classroom,</i> • <i>visits to companies and laboratories (incl. exercises) should be possible,</i> • <i>real materials and tools are being used.</i>
9.	Media and resources	<p>Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems.
10.	Assessment methods	<ul style="list-style-type: none"> • systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.

LWA 02 PTT: Monitoring and programming Industry 4.0 production using digitalized technology

1.	LWA	LWA 02 PTT: Monitoring and programming Industry 4.0 production using digitalized technology
2.	Assigned to Core Work-process	Module 02 PTT: Professional Development Training for TVET teachers in Industry 4.0
3.	Time frame	18 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>Industry 4.0 is integrating a variety of different technologies into a complete system. The most important features of this system are the intelligence of the individual components and the way that these components network with smart factories. Achieving this function requires collecting information from intelligent sensors and actuators and the programming of PLCs. This requirement will be at the center of the teaching and learning. It will be the main requirement for the teaching process and methods are needed for how to teach it.</p> <p>The capability to ensure an optimized function of a smart factory through operating with available data and programming of the components and systems is a core competence needed by all skilled workers. These steps in using technology support the software-based communication between Cyber Physical Systems, internet and machinery.</p> <p>The activities have to be supported by the necessary adaption and changes in the work-processes and by optimizing the use of energy.</p>

6.	Widening of competence²¹ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Collect, analyze and explain the flow of information in digitalized systems using intelligent sensors,</p> <ul style="list-style-type: none"> • knowledge of the importance of data for different sensors, • capability to make use of data from sensors, • able to work with different data formats , • ensure the operation of a smart factory by using available data, • identification of malfunctions in the dataflow, • able to optimize the technical and organizational processes of a smart factory • evaluate the process data for optimizing system efficiency. <p>Carry out the operation (programming) of station control PLCs,</p> <ul style="list-style-type: none"> • capability to optimize the flow of material, • use of data to locate the material and optimize the flow via changes in the software program, • re-programming of plant functions with the help of PLCs, • identification of malfunctions with the help of diagnosis instruments if material flow is interrupted, • problem solving if interruptions are relevant. <p>Ability to understand the technological and organizational changes of the work-processes in manufacturing,</p> <ul style="list-style-type: none"> • visualizing processes and material flow, • understanding of processes as a prerequisite for optimizing them, • knowledge of different organizational concepts of high-tech plants, • handling of high-tech plants to ensure safe processes.
7.	Entry prerequisites	<ul style="list-style-type: none"> • background in industrial automation, • approx. 3 years of working experience in vocational education and training or industry, • knowledge and skills in sensors and actuators, • knowledge and skills in PLC, HMI, BUS technologies, SCADA, • basics in teaching in TVET, • experience working in TVET/industries, • capable of innovative teaching and learning, • ability to work in innovative teams, • quality conscientiousness • ability in documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • trainer is acting as a facilitator • high share of self-learning phases (information, planning, decision making, execution, controlling and evaluation), • group work and other social forms should be introduced, • teaching & learning with LWA will be carried out in a combined (theory/practice) special classroom, • visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.
9.	Media and resources	<p>Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems.

21 The types of "competence" will be described in a paper "explanation of terms".

10.	Assessment methods	<ul style="list-style-type: none"> • systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.
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LWA 03 PTT: Optimizing industry processes based on Industry 4.0

1.	LWA	LWA 03 PTT: Optimizing Industry Processes based on Industry 4.0
2.	Assigned to Core Work-process	Module 02 PTT: Professional Development Training for TVET teachers in Industry 4.0
3.	Time frame	18 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>All the working areas in a smart factory are confronted with the new technology and software for the use of Cyber Physical Systems and the communication between the machinery and software monitored with the help of different types of instruments. In this LWA, access to this new level of production concepts and technology is at the center of learning activities as there are</p> <ul style="list-style-type: none"> • software-based communication between Cyber Physical Systems, software, internet and machinery • new technologies for sensors/actuators, RFID chips, process organization via “Manufacturing Execution Systems (MES)”, • digitalization and visualization of the whole production processes. <p>Upgrading of teaching skills in the context of complex technology and related to work-processes have to be at the core of this LWA. Teachers have to get access to the intelligence of the individual components and the way these components network with smart factories. This will be main requirement for a teaching process and methods are needed for how to teach it.</p>
6.	Widening of competence²² Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Identify the design structure of Industry 4.0 factories: sensors/actuators, process modules, cells, networking, process and operation command level, MES,</p> <ul style="list-style-type: none"> • availability of know-how of the structure of smart factories and the technology in use, • knowledge about the function of networks, sensors/actuators, processes of digital functions, • analyze the operation of a smart factory, • capability to optimize the technical and organizational processes of a smart factory. <p>Create the flow of material: using RFID to identify products that need to be manufactured,</p> <ul style="list-style-type: none"> • capability to optimize the flow of material, • use of RFID chips to locate the material, • able to use sensor data for optimizing the material flow, • identification of malfunctions with the help of diagnosis instruments if material flow is interrupted, • problem solving if interruptions are relevant, • use of laboratories.

22 The types of “competence” will be described in a paper “explanation of terms”.

6.	Methodological competence Personal and social competence	Manage “Manufacturing Execution Systems (MES)”: creating, managing, controlling, and visualizing orders on the value-adding process level, <ul style="list-style-type: none"> • visualizing processes and material flow, • explanation of different organizational approaches, • optimizing processes by following MES concept, • handling of visualizing instruments.
7.	Entry prerequisites	<ul style="list-style-type: none"> • background in industrial automation, • approx. 3 years of working experience in vocational education and training or industry, • knowledge and skills sensors and actuators, • knowledge and skills in RFID, NFC, etc. • knowledge and skills in PLC, HMI, BUS technologies, SCADA • basics in teaching in TVET, • experience with working in TVET/industries, • capable of innovative teaching and learning, • ability to work in innovative teams, • quality conscientiousness • ability in documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • trainer is acting as a facilitator • high share of self-learning phases (information, planning, decision making, execution, controlling and evaluation), • group work and other social forms should be introduced, • teaching & learning with LWA will be carried out in a combined (theory/practice) special classroom, • visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.
9.	Media and resources	Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required: <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems.
10.	Assessment methods	<ul style="list-style-type: none"> • systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.

LWA 04 PTT: Planning of teaching lessons and use of multifunctional didactical approaches for a deeper understanding of digital-based modern production

1.	LWA	LWA 04 TT: Planning of teaching lessons and use of multifunctional didactical approaches for a deeper understanding of digital-based modern production
2.	Assigned to Core Work-process	Module 02 PTT: Professional Development Training for TVET teachers in Industry 4.0
3.	Time frame	6 hours
4.	Group size	Max. 25 participants

5.	Description of contents of LWA	<p>LWA 04 PTT is identical in concept to LWA 04 TT but differs in the context!</p> <p>The changes in the world of work because of the 4th Industrial Revolution (Industry 4.0) require continuous teacher training and the use of sophisticated didactical approaches. In this module, different didactical approaches will be used for planning of lessons to support problem-based learning and self-reliant learning processes. Social forms of learning will also play a role, including role-playing, teamwork, portfolio work and others.</p> <p>Based on the target to create a deeper understanding of the impact of digitalization on skilled work and to be able to operate automated systems, training lessons will be designed to use sophisticated didactical approaches for developing competences of teachers and trainers to be able to train their students in this field. The capability to make use of modern digital equipment and simulators, of different media, data bases and other equipment will also be developed. Didactical ways of using such instruments in different learning situations will be clarified.</p>
6.	Widening of competence²³ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Plan learning units in the context of Industry 4.0,</p> <p>Introduce modern didactical approaches within the teaching of Industry 4.0 to enable students and trainees to work freely, self-reliantly and problem-orientedly,</p> <ul style="list-style-type: none"> • planning of lessons by using didactical approaches which allow innovative teaching and learning, • planning and implementing lessons, which make use of digital equipment, digital machinery, simulation and others, • capability to plan and implement lessons which support problem-based and self-reliant learning, <p>Train in the soft skills needed for the digitalized world, especially the competences of networking and communication, flexibility, keeping updated with languages,</p> <ul style="list-style-type: none"> • facilitate an autonomous process of learning to develop specific technical skills needed for handling of the different media measures, instruments, laboratory equipment etc., • experience-based learning, • create learning situations which allow for the development of a deep understanding of the function of digitalized technology, • use language of Industry 4.0, • use teamwork, work in focus groups, work with different social approaches (fishbowl etc.), • apply different approaches of problem-solving, • document and present findings of quality and human-oriented work. <p>Carry out practical exercises in a lab,</p> <ul style="list-style-type: none"> • analyze signal flow with the help of equipment in a lab, • carry out programme exercises in a lab • visit to companies to discuss flexibility, work pressure, types of work organization and consequences.
7.	Entry prerequisites	<ul style="list-style-type: none"> • basics in teaching in TVET, • experience with working in TVET/industries, • capable of innovative teaching and learning, • ability to work in innovative teams, • quality conscientiousness, • ability in documentation and presentation.

23 The types of "competence" will be described in a paper "explanation of terms".

8.	Method of delivery	<ul style="list-style-type: none"> • trainer is acting as a facilitator • high share of self-learning phases (information, planning, decision making, execution, controlling and evaluation), • group work and other social forms should be introduced, • teaching & learning with LWA will be carried out in a combined (theory/practice) special classroom, • visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.
9.	Media and resources	<p>Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems.
10.	Assessment methods	<ul style="list-style-type: none"> • systematic and precise documentation of the teaching and learning process, • assessment/evaluation of the teaching and learning approach and process, • each participant documents the work tasks in his/her own portfolio.

Description of Modules 03 and LWA

Module 03 CTT – Curriculum Design for Industry 4.0 Work-Process	
Training Module Title	Curriculum Design for Industry 4.0 work-process
Responsible Person	NN
Target group	TVET teachers
Module Description	<p>This module is designed for the development of work-process-oriented curricula fit for I 4.0, in particular focusing on the labor market demands. In this context, it is important to include the social implications of work in relation to each specific cultural context to ensure sustainability. It will also be introduced into a learning and teaching model (e. g. self-reliant learning) to demonstrate the implementation of work-process-based standards.</p> <p>This course/module will develop the participants' abilities to carry through work-process analyses for curriculum development and apply the self-reliant learning model in developing competences that will respond to labor market needs.</p>
Module Prerequisites	At least 1-year teaching experience in TVET with pedagogical background (in view of the duration of the course)
Learning Outcomes	<p>The participants will be able to</p> <ul style="list-style-type: none"> • explain the importance of curricula as the backbone for quality learning processes in TVET, • differentiate approaches used to develop a curriculum related to I4.0 in the context of TVET, • decide on the best way of curriculum development in relation to the required competences and work-processes, • analyze industry-related work-processes, • design and develop work-process based curricula, • implement (plan, conduct, evaluate, document) a self-reliant learning model linked to a work-process based curriculum, • evaluate work-process based curricula.

Module 03 CTT – Curriculum Design for Industry 4.0 Work-Process	
Module content	<p>Major topics that will be covered during this course include:</p> <ul style="list-style-type: none"> • Curriculum Design in the context of I4.0 <ul style="list-style-type: none"> – Overview of I4.0 – Curricula as the backbone of quality TVET • Labor market <ul style="list-style-type: none"> – Current demands – Skills anticipation – 21st century skills – Competences required for I4.0 • Approaches for Curriculum Design and Development • Work-process based curriculum <ul style="list-style-type: none"> – state-of-the-art curriculum (work-process-based curriculum) – curriculum design suited to I4.0 • Guidelines for development of advanced detailed curriculum work-process analyses, <ul style="list-style-type: none"> – development of draft advanced occupational standards, – development of advanced detailed curricula, – steps for the development of advanced detailed curricula, – dimensions of curricula, • Application of self-reliant learning approach • Curriculum Evaluation
Course Duration	1 week (40 hours) (Alternative: 65 hours)
Delivery Methods	<p>Indicate how the course is delivered:</p> <p><input checked="" type="checkbox"/> In-class instruction</p> <p><input type="checkbox"/> Distance education</p> <p><input checked="" type="checkbox"/> Workshop</p> <p><input type="checkbox"/> Laboratory</p> <p><i>Comments: Company visit and visit to a high-tech Lab at a TVET center will be included.</i></p>
Didactical comments	<p>The objective of the module is an introduction to work-process-related curriculum development. Input of the principles of how curricula have to be designed will be given. An example of the development of a curriculum has to be carried through by the participants to foster a clear understanding of the requirements for curriculum development. Examples for the design itself have to be offered by the facilitator.</p> <p>The application of the self-reliant learning model in developing competences will be a further topic in the module.</p>
Learning environments	<p>Classroom and Workshop</p> <ul style="list-style-type: none"> • Classroom: for theoretical background (flip chart, board. Digital media); • Company for analyzing needs and work-processes. <p>Blended learning approach (group work and presentation, lecture) and on-site visits</p> <p>Participants carry through work-process analyses in companies, and present outcomes of the work-process analyses and development of the standards and curriculum.</p>

Module 03 CTT – Curriculum Design for Industry 4.0 Work-Process	
Material/Literature	<p>Boreham, N., & Fischer, M. (2009). The Mutual Shaping of Work, Vocational Competence and Work-process Knowledge.</p> <p>In R. Maclean & D. N. Wilson (Eds.), <i>International Handbook of Education for the Changing World of Work</i> (pp. 1593–1610). Bonn: Springer.</p> <p>Becker, M. & Spöttl, G. (2015). Berufliche (Handlungs-)Kompetenzen auf der Grundlage arbeitsprozessbasierter Standards messen. In <i>bwp@ Berufs- und Wirtschaftspädagogik-online</i>, Issue 28, 1-33. Online: http://www.bwpat.de/ausgabe28/becker_spoettl_bwpat28.pdf (22-06-2015).</p> <p>Dreyfus, H. L. & Dreyfus, S. E. (1986). <i>Mind over Machine. The Power of Human Intuition and Experience in the Era of the Computer</i>. New York: Free Press.</p> <p>Hiim, H. (2017). Ensuring curriculum relevance in vocational education and training: epistemological perspectives in a curriculum research project. <i>International journal for research in vocational education and training</i>, Issue,1 (4), 1–19. Retrieved from URN: urn:nbn:de:0111-pedocs-140476.</p> <p>Lave, J. & Wenger, E. (1991). <i>Situated Learning. Legitimate Peripheral Participation</i>. New York, Cambridge: Cambridge University Press.</p> <p>Spöttl, G. & Loose, G. (2015). Transformation and Globalization in Technical, Vocational Education and Training – Which Way Should TVET Take? <i>International Journal of Vocational Education and Training</i>, Issue, 2 (23), 28–45.</p> <p>Spöttl, G. & Loose, G. (2018). Work-process based Development of Curricula: A framework. In: <i>TVET@Asia</i>, issue 11, 1–17. Online: http://www.tvet-online.asia/issue11/spoettl_loose_tvet11.pdf (retrieved 30.06.2018).</p> <p>Spöttl, G., Loose, G. & Becker, M. (2019). <i>Developing a Work-Process Based Curriculum</i>. Frankfurt am Main: Peter Lang (in press).</p> <p>Spöttl, G.; Tutlys, V. (2017). From the analysis of work-processes to designing competence-based occupational standards and vocational curricula. <i>European Journal of Training and Development</i>, Issue, 1 (41), 50–66.</p> <p>Stenhouse, L. (1975). <i>An Introduction to Curriculum Research and Development</i>. London: Heinemann.</p>

Module 03 CTT: Curriculum Design for Industry 4.0 Work-Process

Generating of LWA

LWA 01 CTT

Curricula are the backbone of learning and teaching and are important for outcome-based learning processes. The discussion of the best curriculum approach is a never-ending issue and a number of solutions are available and in use. This is the first and most important topic when it comes to curriculum design and development. Curriculum designers and teaching personnel have to be able to decide on the priority of the respective curriculum approach. The learning outcomes underpin the necessity of clarifying the role and the importance of different approaches and their best use:

- differentiate approaches used to develop curriculum related to Industry 4.0 in the context of TVET,
- decide on the best method of curriculum development in relation to the required competences and work-processes,

During the training, an overview should be given of the latest and most important approaches. This learning process should enable curriculum designers to understand the advantages and disadvantages of different approaches and to work out certain priorities for the use of a respective approach. Also during the training, the so-called work-process-related approach should be given priority due to the manifold requirements of Industry 4.0.

The contents under discussion can be summarized as follows:

- curriculum design in the context of Industry 4.0
 - overview of Industry 4.0
 - curricula as the backbone of quality TVET
- labor market
 - current demands
 - skills anticipation
 - 21st century skills
 - competences required for IR4.0
- approaches for Curriculum Design and Development
- work-process-based curriculum
 - state-of-the-art curriculum (work-process-based curriculum)
 - curriculum design fit for Industry 4.0.

Linked to this content, topics and the outcomes the LWA might be defined as follows:

LWA 01 CTT: Selecting curriculum development approaches for Industry 4.0 in the context of TVET

The definition of the LWA already establishes the relationship with Industry 4.0. This already proves that alternative answers – also within the curriculum design – will become necessary in the light of an optimization of process sequences.

LWA 02 CTT

Today it is necessary to incorporate the requirements of digitalization and Industry 4.0 during curriculum development. In order to optimize the processes and work organization within the implementation of digitalized equipment or Industry 4.0 approaches, it is necessary to take care of such issues within the curriculum development. With the help of so-called work-process analyses, process-related requirements in companies can be identified. This is also required for the learning outcomes, where participants will be able to:

- analyse industry-related work-processes.

The core issue of this LWA is to train participants to conduct work-process analysis and to transfer the outcomes into standards and a curriculum structure. In the module contents, the importance of this step is underpinned:

- demand of labor market,
- guidelines for development of advanced curriculum
 - work-process analysis,
 - development of draft advanced occupational standards.

The definition of the LWA could be as follows:

LWA 02 CTT: Conducting industry-related work-process analyses

The implementation of this LWA requires a visit to carefully selected companies with best practice in the use of modern technology in order to get a deeper insight of future-oriented developments. Another requirement is the transfer of the outcome of the analysis into a curriculum design.

LWA 03 CTT

LWA 03 is focusing on the development of detailed curricula. Main areas are the definition of curricula for certain target groups and the use of the instruments for the development of work-process-related curricula. The learning outcomes will enable participants to:

- design and develop work-process-based curricula.

The learning outcomes confirm the target of the curriculum development process and are supported by the module contents:

- development of advanced detailed curricula,
 - steps for the development of advanced detailed curricula,
 - dimensions of curricula.

This means that the instruments of the development of work-process-based curricula have to be used in practice.

The definition of the LWA is:

LWA 03 CTT: Designing and developing work-process based curricula

In the context of digitalization and Industry 4.0, the use of the work-process-based approach for curriculum development is an innovative step.

LWA 04 CTT

The 4th LWA goes a step further by intending to plan a training lesson using the self-reliant approach interlinked with a work-process-based curriculum. The learning outcome is defined as the participants' ability to:

- implement a self-reliant learning model linked to a work-process-based curriculum
 - plan,
 - conduct,
 - evaluate,
 - document.

Some theoretical background is required to make use of the self-reliant approach and a work-process-based curriculum. The module contents support this step:

- application of the self-reliant learning approach.

Based on this, the LWA could be defined as follows:

LWA 04 CTT: Implementing a self-reliant learning model linked to a work-process-based curriculum

A successful transfer of a self-reliant approach and a work-process-based curriculum linked to digitalization will be a very innovative step and highly support quality development.

LWA 05 CTT

The evaluation of the curriculum should only be done from the perspective of the teaching process in order to modify some aspects if the logic of the design does not fit. After undergoing the learning activities of this module, the learner should be able to:

- identify the advantages and limitations of the work-processed-based curriculum using a curriculum evaluation tool
- propose improvements to modify aspects of the design to enhance the learning and teaching process. Based on this, an LWA for evaluation could be defined as follows:

LWA 05 CTT: Evaluating work-processes-based curricula

LWA 01 CTT: Selecting curriculum development approaches for Industry 4.0 in the context of TVET

1.	LWA	LWA 01 CTT: Selecting curriculum development approaches for IR 4.0 in the context of TVET
2.	Assigned to Core Work-process	Module 03 CTT: Curriculum Design for Industry 4.0 Work-process
3.	Time frame	6 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	This LWA covers the different approaches used to develop curricula in the context of TVET according to the requirements of relevant industries for IR 4.0. The focus of this LWA is on acquiring the fundamental competence to develop curricular structures and designing work-process-related curricula in line with demands of digitalization. This approach is an innovative step in curriculum development.
6.	Widening of competence²⁴ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<ul style="list-style-type: none"> • Explain the importance of curricula as the backbone for quality learning processes in TVET, • Differentiate approaches used to develop curricula related to IR4.0 in the context of TVET: • Compare and contrast the advantages and disadvantages of different approaches for curriculum development, • Explain specific issues of work-process-based curricula, • Decide on the best way for curriculum development related to the required competences and work-processes.

24 The types of "competence" will be described in a paper "explanation of terms".

7.	Entry prerequisites	<ul style="list-style-type: none"> • Basics in teaching in TVET, • Experience with working in TVET/industries, • Capable of innovative learning and teaching, • Ability to work in innovative teams, • Quality conscious, • Ability in documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainer is acting as a facilitator • High share of self-reliant learning phases (information gathering, planning, decision making, executing, controlling and evaluating), • Group work and other forms of collaborative learning should be introduced, • Teaching & learning with LWAs will be carried out in a combined (theory/practice) special classroom, • Visits to companies and laboratories (incl. exercises) should be possible, • Real materials and tools are being used
9.	Media and resources	<p>Apart from the traditional media (PC, projector, flip chart etc.) the following additional media are required:</p> <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems, • digitalized media • sample work-processes • sample work-process based curricula.
10.	Assessment methods	<ul style="list-style-type: none"> • Systematic and precise documentation of the learning and teaching process, • Assessment/evaluation of the learning and teaching approach and process, • Each participant documents the work tasks in his/her own portfolio.

LWA 02 CTT: Conducting industry-related work-process analysis

1.	LWA	LWA 02 CTT: Conducting industry-related work-process analysis
2.	Assigned to Core Work-process	Module 03 CTT: Curriculum Design for Industry 4.0 Work-process
3.	Time frame	12 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	<p>Conducting a work-process analysis is a prerequisite for the development of work-process-related standards and curricula. The standards of work-process will be defined based on the material and activities in the industry related work performed in companies. These activities in the industry-related work will be used for categorizing the most important core work-processes met within the analysis process and structured according to a concept that enables a beginner to develop into an expert. The categories are the backbone for the definition of the standards and curricula.</p>

6.	Widening of competence²⁵ Professional competence (vocational and didactical) Methodological competence Personal and social competence	Analyse industry-related work-processes <ul style="list-style-type: none"> • observe the steps of work-process, • categorise work-processes, • define the most important core work-processes met within the analysis process, • collect data to obtain an excellent foundation for learning processes including <ul style="list-style-type: none"> – labor market needs – specific issues of work-process-based curricula – interlinkage of digitalization, • conduct work-process analysis at the shop floor level, • identify core work-processes and related competences.
7.	Entry prerequisites	<ul style="list-style-type: none"> • Basics in teaching in TVET, • Experience with working in TVET/industries, • Capable of innovative learning and teaching, • Ability to work in innovative teams, • Quality conscious, • Ability in documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainer is acting as a facilitator • High share of self-learning phases (information gathering, planning, decision making, executing, controlling and evaluating), • Group work and other social forms should be introduced, • Teaching & learning with LWA will be carried out in a combined (theory/practice) special classroom, • Visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.
9.	Media and resources	Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required: <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems, • digitalized media • sample work-processes • sample work-process based curricula.
10.	Assessment methods	<ul style="list-style-type: none"> • Systematic and precise documentation of the learning and teaching process, • Assessment/evaluation of the teaching and learning approach and process, • Each participant documents the work tasks in his/her own portfolio.

LWA 03 CTT: Designing and developing work-process based curricula

1.	LWA	LWA 03 CTT: Designing and developing work-process-based curricula
2.	Assigned to Core Work-process	Module 03 CTT: Curriculum Design for Industry 4.0 Work-process
3.	Time frame	12 hours

25 The types of "competence" will be described in a paper "explanation of terms".

4.	Group size	Max. 25 participants
5.	Description of contents of LWA	The output of the work-process-analysis is used for the curriculum design based on the actual competences for work involving high-technology (digitalization) and society requirements; we need a curriculum that progresses beyond “narrow” skills to “broad” competences which enable the learner to cope with uncertainty and change in the workplace. The use of ADDIE and PDCA curriculum development models will also be introduced in this LWA.
6.	Widening of competence²⁶ Professional competence (vocational and didactical) Methodological competence Personal and social competence	Design and develop work-process-based curricula <ul style="list-style-type: none"> • select instruments for the development of curricula, • categorise the material from the work-process analysis for the definition of core work-processes, • generate standards based on core work-processes, • develop a curriculum based on the core work-processes by using the available instruments, • define the level of a certain curriculum for a target group in question, • identify terms of competences for different levels (basic, intermediate, advance) of a curriculum, • design a curriculum structure for different levels, • collate the different competence categories into a curriculum.
7.	Entry prerequisites	<ul style="list-style-type: none"> • Basics in teaching in TVET, • Experience with working in TVET/industries, • Capability of innovative learning and teaching, • Ability to work in innovative teams, • Quality conscious, • Ability in documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainer is acting as a facilitator • High share of self-learning phases (information gathering, planning, decision making, executing, controlling and evaluating), • Group work and other social forms should be introduced, • Teaching & learning with LWAs will be carried out in a combined (theory/practice) special classroom, • Visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.
9.	Media and resources	Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required: <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems, • digitalized media • sample work-processes • sample work-process-based curricula.
10.	Assessment methods	<ul style="list-style-type: none"> • Systematic and precise documentation of the learning and teaching process, • Assessment/evaluation of the teaching and learning approach and process, • Each participant documents the work tasks in his/her own portfolio.

26 The types of “competence” will be described in a paper “explanation of terms”.

LWA 04 CTT: Implementing a self-reliant learning model linked to a work-process-based curriculum

1.	LWA	LWA 04 CTT: Implementing a self-reliant learning model linked to a work-process-based curriculum
2.	Assigned to Core Work-process	Module 03 CTT: Curriculum Design for Industry 4.0 Work-process
3.	Time frame	6 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	This LWA covers the application of a learning model related to the self-reliant learning process. The focus of this LWA is on acquiring the competences to organise a SRL learning model aligned with a work-process-based curriculum. This includes planning, conducting, evaluating and documenting the learning situations.
6.	Widening of competence²⁷ Professional competence (vocational and didactical) Methodological competence Personal and social competence	Implement a self-reliant learning model linked to a work-process-based curriculum: <ul style="list-style-type: none"> • Plan • Conduct • Evaluate • Document
7.	Entry prerequisites	<ul style="list-style-type: none"> • Basics in teaching in TVET, • Experience with working in TVET/industries, • Capable of innovative learning and teaching, • Ability to work in innovative teams, • Quality conscious, • Ability of documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainer is acting as a facilitator • High share of self-learning phases (information gathering, planning, decision making, executing, controlling and evaluating), • Group work and other social forms should be introduced, • Teaching & learning with LWAs will be carried out in a combined (theory/practice) special classroom, • Visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.
9.	Media and resources	Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required: <ul style="list-style-type: none"> • safety instruction data sheets provided by the trainer, • specialist textbooks for digitalization, • online learning tools or management systems, • digitalized media • sample work-processes • sample work-process-based curricula.

27 The types of "competence" will be described in a paper "explanation of terms".

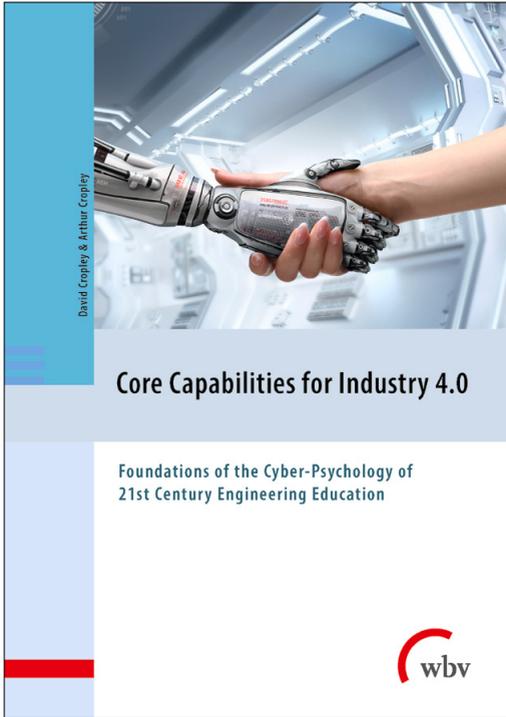
10.	Assessment methods	<ul style="list-style-type: none"> • Systematic and precise documentation of the learning and teaching process, • Assessment/evaluation of the teaching and learning approach and process, • Each participant documents the work tasks in his/her own portfolio.
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LWA 05 CTT: Evaluating work-process based curriculum

1.	LWA	LWA 05 CTT: Evaluating work-process based curriculum
2.	Assigned to Core Work-process	Module 03 CTT: Curriculum Design for Industry 4.0 Work-process
3.	Time frame	4 hours
4.	Group size	Max. 25 participants
5.	Description of contents of LWA	This module covers the knowledge, skills and values in evaluating work-process-based curriculum according to the requirements of IR 4.0. The evaluation of the curriculum is made from the perspective of the learning and teaching process to modify some aspects if the logic of the design does not fit.
6.	Widening of competence²⁸ Professional competence (vocational and didactical) Methodological competence Personal and social competence	<p>Evaluate work-process-based curricula</p> <ul style="list-style-type: none"> • identify the advantages and limitations of the work-process-based curriculum using a curriculum evaluation tool, • propose improvements to modify aspects of the design to enhance the learning and teaching process
7.	Entry prerequisites	<ul style="list-style-type: none"> • Basics in teaching in TVET, • Experience with working in TVET/industries, • Capable of innovative learning and teaching, • Ability to work in innovative teams, • Quality conscious, • Ability of documentation and presentation.
8.	Method of delivery	<ul style="list-style-type: none"> • Trainer is acting as a facilitator • High share of self-learning phases (information gathering, planning, decision making, executing, controlling and evaluating), • Group work and other social forms should be introduced, • Teaching & learning with LWA will be carried out in a combined (theory/practice) special classroom, • Visits to companies and laboratories (incl. exercises) should be possible, • real materials and tools are being used.

28 The types of "competence" will be described in a paper "explanation of terms".

9.	Media and resources	Apart from the traditional media (PC, projector, flip chart etc.), the following additional media are required: <ul style="list-style-type: none">• safety instruction data sheets provided by the trainer,• specialist textbooks for digitalization,• online learning tools or management systems,• digitalized media• sample work-processes• sample work-process based curricula.
10.	Assessment methods	<ul style="list-style-type: none">• Systematic and precise documentation of the learning and teaching process,• Assessment/evaluation of the curriculum evaluation results (checklist),• Each participant documents the work tasks in his/her own portfolio.



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David Cropley, Arthur Cropley

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21st Century Engineering Education

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This volume presents a further training concept on Industry 4.0 for TVET Personnel, which was developed for international use by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH together with SEAMEO Regional Centre for Vocational and Technical Education and Training (SEAMEO VOCTECH) and the ASEAN (Association of Southeast Asian Nations) member states.

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