



MetaTech Exchange

BRIDGING INDUSTRY 4.0 IN WESTERN BALKANS

RECOMMENDATIONS FOR USER INSTITUTIONS

**"STEP-BY-STEP GUIDELINES AND
INSTRUCTIONS FOR PROGRAM
IMPLEMENTATION"**



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1. Executive Overview

The development of manufacturing technologies and the widespread use of digitalization in every area of life pose a significant challenge for both employees and employers, requiring a change in their approach to vocational education. This challenge also encompasses vocational education in its broadest sense, which includes vocational training centers and institutions that offer VET (Vocational Education and Training). Implementing these changes is a necessary condition for fully adopting modern production technologies and fully utilizing the efficiency associated with the use of modern machinery and digital technologies. Therefore, this publication includes information and guidelines that can assist in implementing tools developed as part of the project, such as the online platform. Due to differences arising from the specific characteristics of a given country or region, it is worth considering, for example, broadening the implementation of the guidelines to some extent and certainly adapting them to current market requirements.

Within the framework of the METATECH 4.0 project, the user institution's recommendation is designed to equip vocational education and training (VET) providers, higher education institutions, training centres, and industry professionals with the guidelines, knowledge and practical skills required to meet the demands of modern metal industry technologies training programme. The programme focuses on emerging technologies such as Artificial Intelligence (AI), CAD/CAM technologies, additive manufacturing (3D printing), 3D modelling, and industry 4.0, enabling participants to apply these technologies effectively in real-world industrial environments. The primary target audience includes vocational educators and trainers, university lecturers, technical instructors, industry professionals, technicians, engineers, students, and lifelong learners seeking to develop competencies in metal industry aligned with Industry 4.0. Institutions implementing the programme should also ensure that trainers possess relevant technical expertise, pedagogical skills, and practical industry experience to deliver high-quality, learner-centred instruction.

Successful implementation requires institutions to provide adequate technical infrastructure, including appropriate laboratory equipment, modern software, reliable digital learning platforms, and safe training environments. The curriculum should combine theoretical knowledge with hands-on practical activities, project-based learning, and industry collaboration to ensure participants develop both technical and problem-solving skills. Continuous professional development

for trainers, regular curriculum updates, and strong partnerships with industry are also essential to maintain relevance as technologies evolve.

User institutions can deliver sustainable, high-quality training that enhances workforce readiness, supports innovation, and contributes to the successful adoption of Industry 4.0 technologies across education and metal industry. The programme promotes lifelong learning, strengthens collaboration between education providers and employers, and prepares learners with the competencies needed to thrive in an increasingly digital and technology-driven economy.

2. Background and context

The metal industry has a long history of resilience and adaptation. As an almost 200-year-old industrial sector, it has continuously sustained its competitiveness by responding to global technological and economic developments. Today, the next major transformation is driven by digitalization, which is reshaping not only production processes but also products, services, communication flows, and business models. For institutions operating in a global market, digital technology is no longer optional. It is a prerequisite for market participation, responsiveness to demand, and long-term success.

Industry 4.0 places digitalization at the center of industrial modernization. The key technologies associated with Industry 4.0 can only deliver their full value when enterprises have already achieved a meaningful level of digital maturity.

The project responds directly to the identified needs of the metal industry and the vocational education and training sector. It aligns closely with the objectives of the Erasmus+ call **ERASMUS-EDU-2024-CB-VET** by addressing the urgent need to strengthen the capacity of VET providers in the metal industry and improve cooperation between public and private stakeholders. The project recognizes that demand-oriented and opportunity-driven VET interventions are essential for supporting workforce adaptation in the era of digital transformation. This project developed Metatech Exchange – Training Content and learning platform. The e-learning platform developed within the framework of the MetaTech 4.0 Project is designed to support training and skills development in Industry 4.0 technologies and tools.

The Metatech Exchange platform is intended for:

- vocational education and training (VET) students,
- higher education students,
- teachers and trainers,
- technicians and industry professionals,
- SMEs and companies interested in digital transformation and smart manufacturing solutions.

The platform provides digital and interactive learning content focused on key Industry 4.0 competences, combining theoretical knowledge with practical, hands-on learning experiences.

The platform supports the development of knowledge and skills related to:

- Industry 4.0 tools and technologies,
- industrial digitalization,
- automation and smart processes,
- digital transformation in manufacturing environments,
- practical applications and technological use cases,
- learning Approach.

Within the resulting platform, attention was focused on those Industry 4.0 tools with the greatest implementation potential, as well as those identified as essential for the development of a given country's economy. To implement these tools, it is important to follow best practices. Therefore, guidelines covering various areas, including technical details, the knowledge of the trainer/course instructor, software, and so on, are presented below.

3. Technical requirements

A key issue in the implementation of project results after its completion is the presentation of guidelines covering technical details, mainly concerning machines, devices and software.

Trainers should demonstrate proficiency in the key following areas which guarantee proper development of skills:

- Fundamental principles of Industry 4.0 and digital transformation.
- Artificial Intelligence (AI) and Machine Learning applications relevant to the training domain.
- Internet of Things (IoT), automation, and smart manufacturing concepts.
- Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) software.
- Additive manufacturing (3D printing) technologies and workflows.
- *Parametric 3D modeling*
- *Product design workflows*
- *Simulation and modeling adjustments*
- Robotics and industrial automation systems.
- Digital twins, simulation tools, and cyber-physical systems.
- Data acquisition, visualization, and basic data analytics.
- Industrial communication protocols and networking fundamentals.
- Cybersecurity awareness in industrial environments.

In selecting technical tools for implementing project results after its official implementation, an e-learning platform is also helpful. It contains information on currently used modern tools/machines, as well as links to websites and other sources supporting the tool selection process.

In terms of technical requirements, it is important to match tools to the actual needs arising from the region's requirements.

A good example is the selection of metrological equipment. In this area, the e-learning platform mentions 3D scanners, but the word "scanner 3D" itself carries a significant meaning. It is important to select the appropriate scanner for training, one that has the features/functions of its large counterpart used in industrial environments, such as a rotary table and dimensional analysis software, as dimensional analysis is its primary application in production line work.

A similar situation occurs with 3D printing systems. It is not necessary to purchase large plastic-based systems for a vocational training center, as a small 3D printing system costing €1,000 provides the same functionality. The situation is different when it comes to training using metal powder 3D printers. In this case, there are no affordable 3D printing systems. It's also important to plan a suitable location for such a system, as it has very stringent safety requirements: separate ventilation, special flooring, face masks with filters, and appropriate tools. It's worth noting that

both 3D scanners and 3D printers require maintenance, and proper maintenance is essential. While a 3D scanner can be operated independently, 3D printing with metal powder requires knowledge of CAD software, materials science, heat treatment, and technical tasks such as calibration, among other things. This means that purchasing equipment must be preceded by securing appropriate staff who can not only conduct training but also operate the systems and periodically improve their skills.

When selecting technical digital tools, such as software supporting the production process (CAM) or CAD design, it's worth considering several issues. If we're focused on learning basic design mechanisms, we can choose a single software and prioritize a low price or lifetime license. However, if we're planning practical training that provides some preparation for independent industrial work after completing the course, we need to conduct market research. This research will allow us to select software used by local or national organizations. In this case, trainees will be able to begin working independently in a position within the company almost immediately. However, this requires appropriate work and analysis. This choice, however, has the added benefit of easier recruitment of training staff/trainers, as these roles can be filled by individuals from the local industrial environment with high competencies and professional experience. Trainers with professional experience are undoubtedly the best choice when looking for individuals responsible for implementing the training. The selection of employees as trainers means that training examples often reflect real-world industrial problems, which increases the training's attractiveness and substantive value.

To properly implement equipment operation training, it is recommended to divide the training hours into a practical portion at a workstation with a 3D printer and scanner, and an online theoretical portion. It is important that the hours are divided into a more practical portion. Online training is acceptable and recommended for theoretical introduction, which can also enable a wider audience to participate.

The implementation of training in the area of artificial intelligence and related tools is advantageous because these tools have only recently entered the market, allowing for a degree of freedom in their selection. When implementing training in this area, it is recommended to select free tools, which will allow students to practice and apply the acquired knowledge in a wide range of applications. It is also recommended to conduct periodic market research regarding the use of AI tools in industrial environments and update the training

offerings in this area. Modern AI tools are developing so rapidly that it's crucial to keep up with software advancements.

A key aspect of the training implemented as part of this project is cybersecurity. This term can be considered either as a separate concept or as a part of all the tools mentioned above. It is recommended to implement two-pronged activities: one focused on cybersecurity as a separate concept and training section, and the other connected with other training areas. Every tool used in the training environment discussed in this project is vulnerable to cybercriminal attacks. Each tool has its weaknesses, often dependent on the knowledge of the operators, which is why it's crucial to include this in the training scope of almost all modules.

An additional aspect that undoubtedly constitutes good practice in vocational education training VET is, above all, individual work on the job. When purchasing equipment such as 3D scanners, CNC machine tools, 3D printers, CAD design software, CAM manufacturing software, artificial intelligence software, cybersecurity and many others, access to and operation of the equipment by a single person is crucial: one machine, one person. Of course, there are situations where such a solution is impossible or difficult to implement, but it's worth remembering that the greater the independence of the trainee during training, the greater the results of this form of training, especially since we're talking about equipment that requires learning from the beginning.

4. Practical Industry Experience

Institutions are encouraged to recruit trainers who have:

- Practical experience working in manufacturing or industrial environments.
- Experience implementing Industry 4.0 technologies in real-world settings.
- Live printing of 3D models, rapid prototyping and modern production technologies.
- Knowledge of current industrial standards and best practices.
- Familiarity with digital production systems and quality assurance processes.
- Experience managing innovation or digital transformation projects.

When hiring trainers with these qualifications, it's important to discuss and clearly define the training objectives, focusing on real-industries examples and problems

encountered in practical work environments. The objectives set in an industrial environment differ slightly from those pursued by individuals without industrial experience, hence the emphasis on hiring individuals with practical experience.

5. Pedagogical Competencies

Effective trainers should possess:

- Adult learning and vocational education methodologies.
- Competency-based curriculum delivery.
- Active learning and learner-centred teaching approaches.
- Ability to facilitate workshops, demonstrations, and laboratory sessions.
- Skills in assessing practical competencies and providing constructive feedback.
- Experience in blended and online learning environments.

When implementing VET training and courses, it's important to ensure appropriate pedagogical preparation. Individuals with such training have the knowledge and competence to conduct classes for a wide audience, taking into account the needs of individuals with disabilities or those requiring additional support.

6. Digital Competencies

Trainers should be comfortable using digital learning technologies, including:

- Learning Management Systems (LMS).
- Video conferencing and virtual collaboration tools.
- Digital assessment platforms.
- Interactive presentation software.
- Virtual laboratories and simulation software.
- AI-assisted educational tools where appropriate.

Best practices for implementing VET education also primarily include the digital skills of trainers. Currently, technological advancements are so advanced that it's impossible to operate machinery, equipment, and programs without a thorough knowledge of both specialized software and general knowledge related to digitalization. System integration is so extensive, and hardware requirements are growing year by year, and even month by month.

Furthermore, it's worth noting that digital skills are essential due to the increasingly recommended implementation of a dual vocational education system, with an undoubtedly large theoretical component in the form of online training. Trainers' digital skills must include, at a minimum, communication using available platforms, presenting content in both audio and video formats, and teamwork between all trainees and the trainer.

Another valuable tip recommended for implementation is active participation in the theoretical component by trainees, which also influences their motivation and allows them to acquire teamwork skills, even at the digital level. Such active participation also requires significant digital skills on the part of the trainer.

7. Equipment Operation Skills

Trainers should be capable of safely operating and demonstrating:

- 3D printers and associated post-processing equipment.
- CNC machines (where applicable).
- Industrial robots and robotic arms.
- PLC systems and industrial controllers.
- IoT development kits and embedded systems.
- Measurement and calibration equipment.
- Laboratory safety equipment.

The issue of safe use of the equipment mentioned above is obvious, but also extremely difficult and responsible. All modern production systems are characterized by a high degree of complexity. In the case of 3D scanners, we may be dealing with a laser system; in 3D printing, we may be dealing with metal powders, lasers, and harmful dusty environments; CNC machine tools are exposed to mechanical hazards; and robots and robotic systems require appropriate procedures. Therefore, when purchasing equipment, it is crucial to ensure appropriate training for trainers in its safe use.

8. Necessary Equipment

An important aspect of proper training implementation is ensuring the training room/laboratory is appropriately equipped to accommodate individuals with special needs and disabilities. Such a facility should be equipped with several examples, as listed below.

- Classrooms may require display screens, projectors, whiteboards, speakers, and seating arrangements suitable for collaborative learning.
- If the training is delivered in a blended format, flexible room arrangements may be necessary.
- Depending on the training model, each learner may require access to a computer or shared device.
- The guidelines should clarify whether one-to-one device access is expected or whether group use is acceptable.
- If the training includes practical exercises, simulations, sensors, or sector-specific tools, these should be listed explicitly. Institutions should know whether such equipment is essential or optional.

9. Software Knowledge

Depending on the specific programme, Institutions should adapt the software list according to available infrastructure and programme objectives.

Trainers should possess working knowledge of software such as:

- CAD software (SolidWorks, Fusion 360, AutoCAD)
- CAM software
- PLC programming environments
- MATLAB or Python for engineering applications
- TensorFlow or PyTorch (for AI-related modules)
- Arduino IDE or Raspberry Pi development environments
- MES/ERP systems (basic operational understanding)
- Data visualization tools (Power BI, Tableau)

10. Continuous Professional Development

Institutions should encourage trainers to engage in ongoing professional development through:

- Industry certifications.
- Participation in conferences, workshops, and seminars.
- Collaboration with industry partners.
- International mobility and exchange programmes.
- Continuous updating of technical and pedagogical skills.
- Participation in research and innovation projects.

11. Minimum Recommended Qualifications

Institutions should encourage trainers to engage in ongoing professional User institutions are encouraged to appoint trainers who possess:

- A bachelor's degree or higher in engineering, e.g., computer science, information technology, manufacturing, mechatronics, mechanical engineering or a related discipline.
- At least three years of relevant industrial or teaching experience in relevant area.
- Demonstrated competence in digital technologies relevant to the training programme.
- Experience delivering vocational education, higher education, or professional training.
- Appropriate health and safety certification where laboratory or industrial equipment is used.

12. Implementation Recommendations for Institutions

Beyond resources and skills, user institutions need practical advice on how to organize training. This recommendation includes guide in planning and delivery of a training.

Industry needs

Institution should identified the needs of Industry in the country or region and based on this planned training.

Conduct readiness assessment

Institutions should first assess whether they have the necessary equipment, software, connectivity, and staff capacity to deliver the training.

Assign responsibilities

Clear roles should be established for trainers, technical support staff, coordinators, and administrators.

Pilot the training

A small pilot session can help institutions identify gaps, test logistics, and make improvements before full delivery. That focus group have to be assess before and after the training.

Monitor delivery

Institutions should track attendance, learner feedback, technical issues, and learning outcomes during implementation.

Document experience

Keeping records of what works well and what needs improvement supports quality assurance and future replication. The best way is to keep it in digital form and make available for trainers and other technical staff so they could improved the process.

Adapt to local context

The training should be flexible enough to fit local institutional conditions (both the software and special industry needs in the aspects of VET) while preserving its core objectives.

To ensure consistent training quality, institutions should:

- Provide regular refresher training for trainers.
- Facilitate collaboration between academia and industry experts.
- Encourage co-teaching with experienced industrial practitioners.
- Maintain access to up-to-date software licences and laboratory equipment.
- Establish trainer evaluation and quality assurance mechanisms.
- Support participation in international knowledge exchange and mobility activities.
- Develop communities of practice to enable trainers to share experiences, teaching materials, and emerging best practices.

13. Assessment methods.

A key issue is clearly defining the method for assessing training completion and assessing progress throughout the training.

These two fundamental issues must be clear not only to the trainer and the institution providing the training, but above all, they must be clearly presented, preferably on the website or in the training materials. The trainee must be familiar with the assessment format before the training begins, as well as with all other aspects of the training. It's also a good idea to include information about the machines, materials, and safety requirements in the course leaflet or on the course website.

14. Quality Assurance and Sustainability

Sustainability is one of the most important goals of this recommendation. The document recommends how to keep using the training materials and implementing training, making them useful over time.

Regular review

Institutions should periodically review the training content to ensure it remains relevant and technically up to date.

It's also worth providing the institution with an additional internal audit, which will help identify the strengths and weaknesses of course implementation and confirm the competence of the training staff. This form of audit is used in higher education and other institutions and helps maintain the high quality of implemented activities.

Updating materials

As software, technologies, or standards evolve, training materials may need revision. Institutions should be encouraged to maintain version control and update records. It is recommended to establish regular meetings and procedures whose purpose will be to periodically analyze possible changes in the way training is carried out.

Institutional integration

Where possible, the training should be embedded into existing programs, modules, or professional development activities.

Capacity retention

Institutions should avoid depending on a single person. Knowledge transfer and team-based implementation are important for continuity. This is particularly important in the context of using advanced equipment where training related to the safe use of machines and devices does not allow for the trainer to be quickly replaced by an external recruit.

Feedback mechanisms

Feedback from trainers, learners, and administrators should be collected and used to improve future delivery – the best way in digital form allow to fast transfer and use by other institution.

Resource planning

Institutions should plan for long-term maintenance, including equipment replacement, software renewal, and staff development.

These sustainability measures ensure that the training remains valuable after project funding or external support ends.

Industry involvement

It is recommended to implement best practices in shaping program content with the participation of industry representatives, which will ensure that the level of education is aligned with the needs of the industry.

Furthermore, the involvement of industry representatives may be reflected in the possibility of conducting some of the training courses by employees of the respective companies, which will enhance the practical aspect of the training.

Involvement of industry representatives may result, for example, in the partial use of their laboratory/industrial facilities and other additional equipment, thus increasing the attractiveness of the training courses.

Coaching

Best practices for implementing innovation in the vocational education industry also include soft skills training and effective coaching. It's worth ensuring that even small-scale motivational and inspiring activities are implemented, which is particularly important for newly inducted employees and can contribute to increased course completion rates and reduced dropout rates. Such activities are worth planning at the initial stages of training.



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