

Supporting skills training for a digital wood and furniture sector

Implementation Guide

SHIFTVET

Digital Transformation for Wood and Furniture VET

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Content

Executive Summary 4
1. Introduction 6
2. Overview of the ShiftVET Project 7
3. Methodology 9
4. Assessment of Digital Technologies for Woodworking VET 11
4.1 Technology Selection Methodology 11
4.2 Assessment of 3D Printing 11
4.3 Assessment of 3D Scanning 12
4.4 Assessment of CNC Machining 13
5. Project Implementation and Results 14
5.1 A2 activities 14
5.2 Trainers' feedback 14
5.3 Students' feedback 15
5.4 Stakeholder Feedback from A3.3 Events 15
5.5 Main lessons learned 17
6. Recommendations for VET Centres 18
6.1 Strategic planning 18
6.2 Equipment 18
6.3 Staff training 19
6.4 Curriculum integration 20
6.5 Sustainability 21
7. Transferability to Other Manufacturing Sectors 23
7.1 Introduction 23
7.2 Cross-sector Transferability Findings 23
7.3 Sector-Specific Transferability 24
7.4 Key Considerations for Transfer 25
8. Good Practices Examples 26
8.1 Introduction 26
8.2 Good practices Identified during ShiftVET 26

9. Step-by-Step Implementation Roadmap 28
10. Policy and Strategic Recommendations 30
10.1 Policy Recommendations 30
10.2 Strategic Recommendations 31
11. Conclusions and Future Outlook 32

Executive Summary

The digital transformation of the manufacturing industries is creating new demands on vocational education and training (VET), requiring training centers to equip students not only with traditional technical skills but also with new digital skills. In the wood and furniture sector, technologies such as additive manufacturing, 3D scanning, and CNC are gradually being incorporated into industrial processes. However, despite their growing importance, their integration into VET programs remains uneven due to limited teaching resources, insufficient teacher training, and the lack of practical guidelines for their implementation.

The ShiftVET project was developed to address this challenge by supporting VET providers in the effective integration of advanced digital technologies into woodworking.

This project brings together a multidisciplinary consortium consisting of a technology center and three specialized vocational training centers in Spain, Italy, and Latvia, which combine their expertise with their extensive educational experience to create practical, transferable, and open-access resources for the vocational training community. The project contributes to the Erasmus+ priorities of digital transformation, innovation in vocational education and training, and increasing the appeal of vocational education and training by promoting modern teaching methodologies and developing future-oriented skills.

Throughout its implementation, ShiftVET follows a phased methodology based on three complementary activities. First, the consortium analysed the potential of various digital technologies for woodworking and developed three guides for trainers, along with an open-access online repository hosting all the results. Second, practical exercises using these three technologies were designed, tested, and validated through their application in the classroom, allowing teachers and students to assess their educational value under real-world conditions. Finally, the transferability of these approaches to other manufacturing sectors was analysed, and this implementation guide was developed to facilitate their widespread adoption by vocational training centers across Europe.

The project focuses on three technologies that demonstrated high educational potential in participating in schools: 3D printing, 3D scanning, and CNC machining. These technologies were selected because they complement existing

woodworking curricula while strengthening students' digital skills, problem-solving abilities, and understanding of modern manufacturing processes. Their implementation also fostered more project-based, collaborative, and student-centred teaching approaches, which increased student engagement and motivation.

This Implementation Guide represents the outcome of the project and consolidates the knowledge generated throughout all project activities. It combines the experience of the consortium, the feedback gathered from trainers, students and external VET centres, and the lessons learned during classroom implementation into a practical reference document. The guide provides strategic recommendations, implementation guidelines, transferability considerations and a step-by-step roadmap to support VET institutions wishing to modernize their programmes through the integration of digital technologies.

Ultimately, ShiftVET demonstrates that the successful digital transformation of VET depends not only on access to technology but also on the availability of high-quality educational resources, well-prepared trainers, institutional commitment and collaboration between education providers and technological organisations.

1. Introduction

Digital technologies are rapidly transforming manufacturing industries, creating new opportunities and new competence requirements for vocational education and training (VET). In the wood and furniture sector, technologies such as 3D printing, 3D scanning and CNC machining are becoming increasingly relevant in industrial practice, making their integration into VET programmes essential for preparing students for the future labour market.

The ShiftVET project was developed to support this transition by providing VET centres with practical resources, teaching methodologies and implementation experiences that facilitate the adoption of digital technologies in woodworking education. Through collaboration between a technology centre and specialised VET providers from Spain, Italy and Latvia, the project developed and validated educational materials, practical activities and recommendations based on real classroom experience.

This Implementation Guide brings together the knowledge and lessons learned throughout the project. It is intended to support VET managers, trainers and other educational stakeholders in planning, implementing and adapting digital technologies within their own training programmes. Alongside practical recommendations, the guide also presents the results obtained during the project, feedback from trainers and students, and guidance for transferring the approach to other manufacturing sectors.

2. Overview of the ShiftVET Project

ShiftVET (Supporting Skills Training for a Digital Wood and Furniture Sector) is an Erasmus+ KA210-VET cooperation partnership aimed at supporting the digital transformation of vocational education and training (VET) in the wood and furniture sector. The project responds to the growing demand for digital competences in manufacturing by promoting the integration of innovative technologies into vocational education through practical, accessible and transferable learning resources.

The consortium brought together four complementary organisations from three European countries, combining expertise in technology transfer, vocational education and curriculum development:

- CETEM (Spain)- Project coordinator and technology centre specialised in research, innovation and technology transfer for the wood and furniture industry.
- IES José Luis Castillo Puche (Spain)- Vocational education provider contributing to the design, implementation and validation of classroom activities.
- ASLAM- ArtWood Academy (Italy)- VET institution specialised in wood and furniture education, responsible for testing and evaluating the developed learning activities.
- Rīgas Mākslas un Mediju Tehnikums (Latvia)- Vocational education provider contributing to the international validation and transferability of the project results.

The project was structured around four Specific Objectives (SO), which guided all activities carried out during its implementation:

- SO1. Identify and evaluate digital technologies with potential for integration into woodworking VET programmes.
- SO2. Develop practical educational resources, including trainer guides and an open online repository supporting the implementation of selected technologies.
- SO3. Design, implement and validate practical classroom activities that enable students to acquire digital manufacturing competences through hands-on learning.

- SO4. Promote the transferability of the developed methodology by producing implementation guidelines and recommendations for other VET providers and manufacturing sectors.

To achieve these objectives, the project was organised into three main technical activities:

Activity 1- Technology Selection and Educational Resource Development

The consortium analysed several emerging technologies relevant to the wood and furniture sector and selected those offering the greatest educational value for vocational training. Trainer guides and supporting learning materials were developed together with an open-access online repository to facilitate their use by VET providers.

Activity 2- Practical Classroom Implementation

Educational exercises based on the selected technologies were designed and tested within the participating VET centres. Trainers and students evaluated the activities under real classroom conditions, providing valuable feedback regarding usability, learning outcomes and educational impact.

Activity 3- Transferability and Implementation

Building on the experience gained during classroom implementation, the consortium assessed the applicability of the developed methodology beyond the project partners. Factsheets describing the adaptation of the approach to additional manufacturing sectors were produced together with this Implementation Guide, which consolidates the project's recommendations and lessons learned into a practical reference document for future adopters.

The main outputs of ShiftVET include trainer guides for the selected technologies, an open educational repository, practical classroom exercises, student projects, technology transfer factsheets and this Implementation Guide. Together, these resources provide a coherent framework that supports VET providers in introducing digital technologies into woodworking education while facilitating their adaptation to other manufacturing contexts.

3. Methodology

The ShiftVET methodology was designed as a progressive, practice-oriented process that combined technology assessment, educational resource development, classroom implementation and validation. Rather than introducing digital technologies directly into VET programmes, the project followed a structured methodology in which each stage built upon the outcomes of the previous one, ensuring that all developed resources were tested under real educational conditions before being incorporated into the final recommendations.

The first phase focused on identifying digital technologies with the greatest potential for woodworking vocational education. The consortium analysed existing technological solutions, reviewed their educational applications and assessed their suitability for VET programmes. Based on this analysis, three technologies were selected due to their accessibility, educational value and relevance to current industrial practices: 3D printing, 3D scanning and CNC machining. Trainer guides and supporting documentation were subsequently developed to facilitate their implementation in educational environments.

The second phase centred on the development and validation of practical learning activities. Existing open educational resources were complemented with new exercises specifically adapted to woodworking VET, which were then implemented by the participating centres during practical classes. Students applied the acquired knowledge through collaborative projects using the selected technologies, providing valuable evidence of their educational effectiveness and practical applicability.

Feedback was collected from trainers and students throughout the implementation process. In addition, external VET providers reviewed the developed materials, assessed their relevance and feasibility, and provided recommendations for future implementation. This combination of technical, pedagogical and institutional perspectives strengthened the validation of the project's results.

Finally, the knowledge generated throughout the project was consolidated into transferable resources, including sectoral factsheets and this Implementation Guide. Together, these outputs provide an evidence-based framework to support

the integration of digital technologies into woodworking education and facilitate their adaptation to other manufacturing sectors.

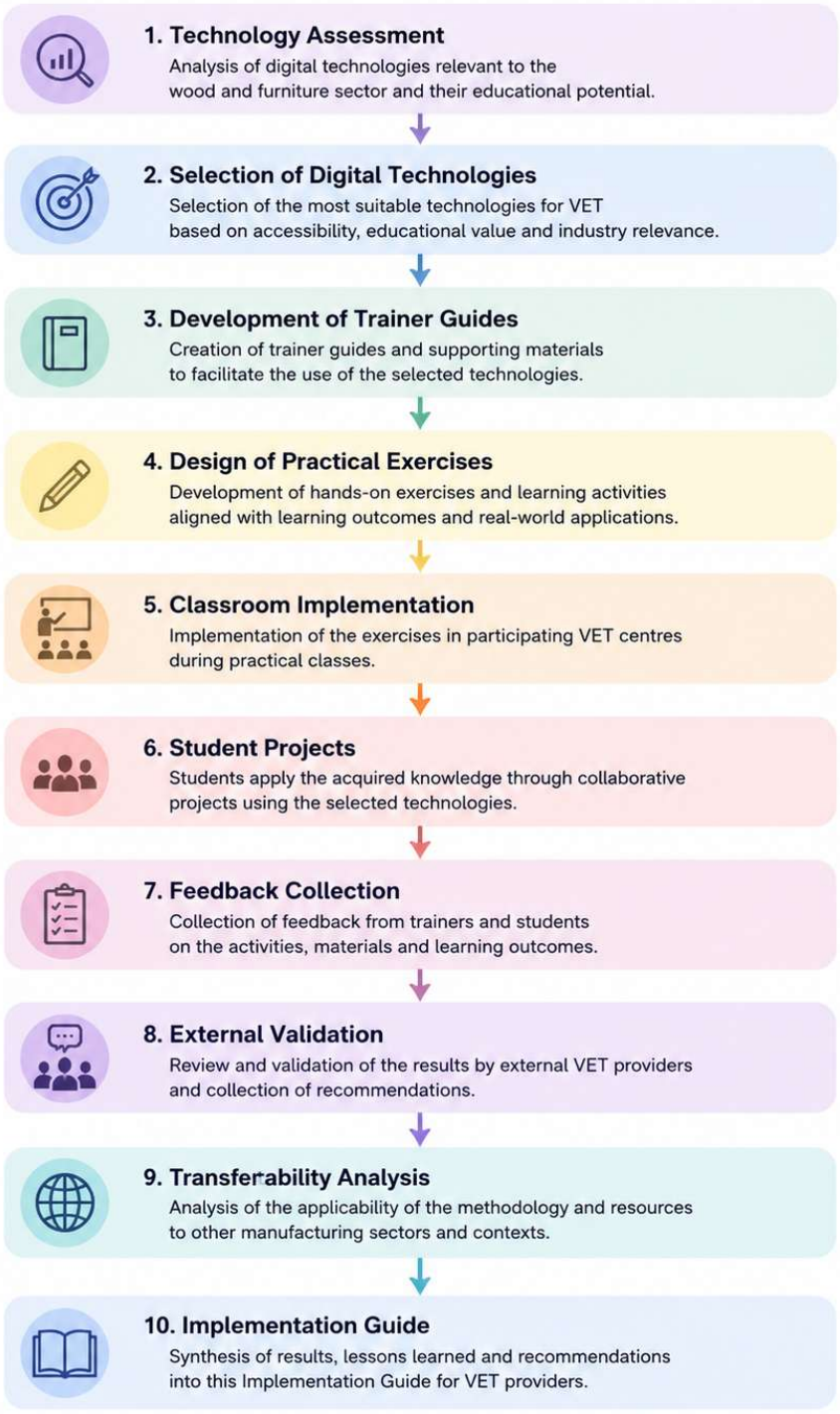


Figure 1: ShiftVET Methodology

4. Assessment of Digital Technologies for Woodworking VET

4.1 Technology Selection Methodology

The selection of the technologies evaluated in the ShiftVET project was based on their educational value, relevance to current industrial practices and feasibility for implementation within initial Vocational Education and Training (i-VET). The objective was to identify digital technologies that could enhance woodworking education while remaining accessible and applicable in VET environments.

The consortium assessed different technologies considering several criteria, including their relevance to the wood and furniture sector, their potential to develop technical and digital competences, their compatibility with existing curricula, the required equipment and infrastructure, and their suitability for hands-on, project-based learning.

As a result of this assessment, three complementary technologies were selected: 3D Printing, 3D Scanning and Computer Numerical Control (CNC) machining. Together, these technologies represent different stages of the digital manufacturing workflow, enabling students to experience processes ranging from digitalisation and rapid prototyping to the production of functional components.

Following their selection, dedicated trainer guides were developed for each technology and validated through practical classroom activities carried out by the project partners. The experience gained during these pilots forms the basis of the assessment presented in the following sections.

4.2 Assessment of 3D Printing

3D printing was identified as one of the most suitable technologies for introducing digital manufacturing concepts into woodworking VET. Its accessibility, ease of use and ability to rapidly transform digital designs into physical objects make it an effective tool for supporting practical and project-based learning. The technology enables students to better understand the product development process while encouraging creativity, experimentation and problem-solving.

During the ShiftVET pilot activities, 3D printing proved to be particularly valuable for developing both technical and transversal competences. Students gained

experience in digital design, printer operation and prototype validation, while also strengthening teamwork, critical thinking and digital skills. The activities demonstrated that the technology can be progressively integrated into existing woodworking curricula without replacing traditional manufacturing techniques but rather complementing them.

The implementation also highlighted several factors for successful adoption. Teachers require basic training in additive manufacturing workflows, and classroom activities should be carefully planned to account for printing times and equipment availability. However, once these aspects are considered, 3D printing offers a flexible and engaging learning environment that increases student motivation and facilitates the understanding of modern manufacturing processes.

Overall, the project confirmed that 3D printing is an effective entry point for the digital transformation of woodworking VET, providing learners with practical experience of digital fabrication while preparing them for increasingly technology-driven industrial environments.

4.3 Assessment of 3D Scanning

3D scanning was also chosen as a technology because it allows students to bridge the gap between physical objects and digital design. By converting real components into digital models, it introduces students to reverse engineering, digital documentation, and product development workflows that are increasingly used in the wood and furniture sector.

During the ShiftVET activities, 3D scanning proved effective in developing students' understanding of digitization processes and their integration with other technologies. Students gained practical and theoretical experience in capturing, processing, and editing 3D models and, in addition, improved their spatial awareness, analytical thinking, and digital skills.

The implementation demonstrated that 3D scanning can be successfully incorporated into vocational training programs through hands-on exercises linked to existing woodworking projects. To maximize its educational value, instructors should provide guidance on scanning techniques, data processing, and the limitations of different scanning methods. Proper lighting conditions and basic equipment setup are also important for obtaining reliable results.

Overall, the project demonstrated that 3D scanning is a valuable educational technology that complements traditional woodworking skills while preparing students for increasingly digital design and manufacturing environments. When combined with 3D printing and CNC machining, it allows students to experience a complete digital workflow, from object capture to production.

4.4 Assessment of CNC Machining

CNC machining was also selected as a key technology given its widespread use in the wood and furniture industry and its relevance to manufacturing processes. This technology enables students to understand how digital designs are transformed into precise, repeatable and functional components, whilst also introducing them to industrial production workflows.

Throughout the ShiftVET activities, CNC technology has proved effective in developing technical skills related to digital manufacturing, including CAD-CAM workflows, machine set-up and precision machining. At the same time, students strengthen their problem-solving, precision and process-planning skills, thereby gaining a better understanding of quality control and efficient production methods.

Practical implementation demonstrates that this technology can be successfully integrated into vocational training in woodworking through hands-on projects that combine digital design with manual fabrication. However, given the complexity of the equipment, successful implementation requires adequate teacher training, stricter safety procedures and careful planning of workshop activities.

Overall, the ShiftVET project confirms that CNC machining is an essential technology for preparing students for today's woodworking industry. Together with the other two technologies, this provides students with a greater understanding of the digital manufacturing process.

5. Project Implementation and Results

5.1 A2 activities

Activity 2 involved a practical validation phase within the ShiftVET project, during which the educational resources developed in Activity 1 were implemented and evaluated in real-world vocational training settings. The overall objective of this activity was to assess the educational value of the selected technologies, identify best practices for integrating them into the classroom, and collect data to support their adoption by VET centres.

The activities were carried out by the three vocational training centres participating in the consortium, where trainers integrated 3D printing, 3D scanning and CNC into practical lessons. Students took part in these activities and learnt about digital design, manufacturing processes and collaborative problem-solving.

Following the practical sessions, the students worked on small projects that required the use of the selected technologies to design, manufacture or validate various woodworking components. These projects fostered creativity, teamwork and independent learning, whilst familiarising the students with the digital manufacturing workflows commonly used in the furniture industry.

The implementation phase also provided an opportunity to evaluate the trainer's guides, classroom exercises and the teaching methodology developed. Feedback gathered from trainers and students confirmed the feasibility of integrating these technologies into VET programmes and provided valuable recommendations for future improvements. The results of the activity form the basis of the recommendations presented throughout this implementation guide.

5.2 Trainers' feedback

The feedback received from trainers during activities A2.2 and A2.3 confirmed the practical feasibility of integrating 3D printing, 3D scanning and CNC machining into vocational training in woodworking. The trainers considered the exercises to be relevant, understandable and flexible enough to be adapted to different educational contexts, equipment and learner profiles.

One of the main strengths identified was the ability to link digital technologies with practical applications in woodworking and to move progressively from

demonstrations to guided activities and student projects. Trainers also highlighted some implementation challenges, in particular the need for sufficient time for practical work, additional support for CNC, CAD/CAM and 3D scanning processes, and activities tailored to different levels of prior experience.

Organisational aspects were also considered important. The availability of workshops, access to equipment, the teaching staff's workload and the academic calendar can all influence implementations. Overall, the trainers' feedback validated the ShiftVET methodology, whilst highlighting that successful integration requires both pedagogical preparation and realistic planning within the vocational training centre.

5.3 Students' feedback

Student feedback was consistently positive across all three participating countries. During Phase A2.2, the 39 questionnaire responses yielded an overall average score of 4.08 out of 5, while the 26 questionnaires collected during Phase A2.3 resulted in a combined average of 4.21 out of 5. These results confirm a high level of satisfaction with the activities and their educational relevance.

Students particularly valued the practical nature of the activities, access to real equipment, teamwork, and the opportunity to achieve tangible results. They also recognized the relevance of 3D printing, 3D scanning, and CNC machining to future professional settings. In Activity A2.3, interest in these technologies reached 4.46 out of 5, and willingness to include similar exercises in future training programs reached 4.31 out of 5.

The main difficulties were related to software use, CNC configuration, scanning processes, and the limited time allocated to hands-on practice. However, these challenges also fostered problem-solving and peer learning. Overall, the feedback confirmed that the ShiftVET approach is engaging, understandable, and relevant to vocational training students.

5.4 Stakeholder Feedback from A3.3 Events

As part of Activity A3.3, three dissemination and validation events were organised in Spain, Italy and Latvia, attended by a total of 89 people. The events brought together vocational training students, teachers, education professionals, management staff and representatives from the business sector. They provided

an opportunity to present the results of ShiftVET and to gather external feedback on the practical integration of 3D printing, 3D scanning and CNC technologies into vocational training.

The feedback received in all three countries confirmed the relevance of these technologies to vocational training and the usefulness of the practical resources developed by ShiftVET. Participants particularly valued the practical activities, real-world examples, guides for trainers, training exercises and accessible teaching materials. These resources were considered useful both for introducing the technologies to teachers with limited prior experience and for supporting the delivery of practical tasks in the classroom.

At the same time, participants identified several common barriers hindering wider implementation. The main challenges related to the initial and ongoing costs of equipment, maintenance and technological updates, the availability of suitable software and technical support, limited time within the timetable and, in particular, the need for teachers to continuously update their digital and technical skills.

The discussions therefore reinforced the importance of continuous, practice-oriented teacher training. Participants recommended combining practical training with clear and reusable support resources, whilst encouraging peer learning and closer collaboration with businesses and technology centres. Such cooperation can help VET providers maintain access to current technologies, professional expertise and real-world industrial applications.

Another common conclusion concerned the transferability of the ShiftVET approach. Participants considered that the methodology is applicable beyond the wood and furniture sector, provided that activities are adapted to the needs of each professional context. Examples discussed during the events included product and interior design, metalworking, mechanics, mechatronics, logistics, electrical installations and work-based programmes.

Finally, the events highlighted that digitalisation should not be seen as a substitute for existing professional knowledge or traditional skills. Particularly in programmes focused on craftsmanship and design, digital technologies can be most effective when combined with manual skills, creativity and established professional practices.

Overall, stakeholders' feedback on A3.3 validated the fundamental principles underpinning the ShiftVET approach: practical learning, accessible teaching resources, continuous development of trainers, realistic planning for equipment and maintenance, interdisciplinary application and adaptation to the specific needs of each VET programme.

5.5 Main lessons learned

The implementation of measures A2.2 and A2.3 has yielded several important lessons for the future integration of digital manufacturing technologies into vocational training.

First, these technologies are most effective when linked to practical and recognizable professional tasks. Students showed greater engagement when 3D printing, 3D scanning, and CNC machining were applied to furniture components, prototypes, and other woodworking-related products.

Second, a progressive learning approach proved particularly effective. Moving from brief explanations and demonstrations to guided exercises and collaborative projects helped students gain confidence and gradually develop greater autonomy.

Third, it is essential to allow sufficient time for practice, especially for more complex processes such as CNC programming, CAD/CAM preparation, and 3D scanning. The implementation also highlighted the importance of adapting activities to students' different profiles and allowing instructors to tailor examples and difficulty levels to their own context.

Finally, the success of the implementation depends not only on the technology itself but also on organizational factors such as equipment availability, staff training, workshop scheduling, and coordination with the academic calendar. Overall, ShiftVET confirmed that these technologies can be successfully integrated into vocational training in woodworking when introduced gradually, linked to real-world applications, and supported by adequate planning.

6. Recommendations for VET Centres

6.1 Strategic planning

The successful integration of digital manufacturing technologies into VET requires careful strategic planning prior to implementation. Rather than introducing new equipment as a one-off investment, VET centres should adopt a structured approach that aligns technology adoption with their educational objectives, institutional priorities and existing resources.

The first step involves defining the expected learning outcomes and identifying how digital technologies can enhance existing training programmes. This includes analysing the skills required by the labour market, reviewing current curricula and determining in which areas these technologies can deliver high educational value. Implementation should complement traditional skills, not replace them, whilst also preparing learners for increasingly digital manufacturing environments.

Institutional commitment is equally important. Centre staff, teaching staff, management and other stakeholders must be involved from the earliest stages of planning to ensure that implementation is backed by adequate resources and a shared vision of the project's objectives. Establishing a phased implementation plan enables institutions to introduce technologies gradually, assess their effectiveness and adjust before extending their use to other courses or programmes.

Finally, VET institutions are encouraged to collaborate with external stakeholders, particularly with businesses and industry representatives, to ensure that the selected technologies and learning activities remain relevant to current industrial practices. Maintaining this dialogue helps to strengthen the link between vocational training and the needs of the labour market, whilst increasing the long-term impact and sustainability of the training provided.

6.2 Equipment

Selecting the right equipment is a key factor in the successful implementation of technology in VET. The choice should be guided by educational objectives, not simply by the acquisition of the most advanced or expensive solutions. The equipment must be appropriate to the students' level, easy to use and maintain, and capable of supporting the practical activities defined throughout the project.

When planning investments, vocational training centres must consider not only the initial costs but also aspects such as maintenance, software licences, consumables and even any necessary technical support. Ensuring compatibility between hardware and software is essential for creating a seamless digital workflow, particularly when combining technologies such as 3D scanning, 3D printing and CNC machining.

The learning environment must also be adapted to accommodate the selected technologies. This includes providing a suitable workspace, ensuring compliance with safety measures and organising the equipment in such a way as to maximise student engagement during practical sessions. Wherever possible, sufficient access to the equipment must be ensured so that students can gain significant practical experience.

Institutions are also encouraged to adopt a phased investment strategy. Starting with essential equipment and expanding resources as expertise and demand grow enables vocational training centres to implement digital manufacturing technologies in a sustainable and cost-effective manner, whilst maintaining the flexibility to adapt to future technological advances.

6.3 Staff training

The successful adoption of digital manufacturing technologies also depends on the preparedness of teaching staff. Educators play a key role in ensuring that these technologies are used effectively and integrated into meaningful learning experiences. Therefore, continuous professional development must be regarded as a priority throughout the entire implementation process.

Before introducing new technologies into the classroom, teachers should receive appropriate training in both technical and pedagogical aspects. This includes building confidence in using 3D printers, 3D scanners and CNC machinery, as well as understanding how to incorporate these tools into classroom learning activities.

Professional development should not be limited to initial training. As digital technologies advance, VET centres must promote continuous learning through workshops, peer-to-peer exchange, collaboration with industry and participation in professional networks. The exchange of experiences amongst teaching staff

also helps to identify effective teaching practices and facilitates the continuous improvement of training activities.

By investing in staff training, VET centres can ensure that educators remain confident in using digital technologies, adapt more easily to new developments and offer learners more realistic and practical experiences. One of the most important factors is having a well-prepared teaching staff capable of successfully and sustainably integrating digital manufacturing into vocational training.

6.4 Curriculum integration

The integration of these technologies into vocational training programmes should be approached as a gradual enhancement of existing curricula, rather than as the creation of new training pathways. Technologies such as 3D printing, 3D scanning and CNC should complement traditional woodworking skills, enabling students to develop technical knowledge and digital skills.

This integration is most effective when technologies are incorporated into practical, project-based activities that mirror real-world industrial processes. Combining design, manufacturing and problem-solving tasks enables students to understand the full production workflow, whilst applying theoretical knowledge in realistic situations. This approach also fosters collaboration, creativity and critical thinking – qualities increasingly valued by employers.

To maximise educational reach and impact, learning activities should be structured progressively, beginning with introductory exercises and gradually increasing in complexity as students gain confidence. This progression enables students to develop a solid understanding of digital manufacturing, whilst ensuring that activities remain aligned with the intended learning outcomes.

Finally, the curriculum content should be reviewed periodically to ensure it continues to reflect technological advances and the sector's changing needs. Maintaining close collaboration with businesses and other stakeholders helps vocational training centres ensure their training programmes remain relevant, equipping students with the skills required for an increasingly digital and innovative wood and furniture sector.

6.5 Sustainability

Ensuring the long-term sustainability of these technologies in vocational education and training requires an ongoing institutional commitment, the regular updating of educational resources and constant collaboration with stakeholders to ensure that training remains relevant.

To maximise the long-term impact of initiatives such as ShiftVET, VET centres should adopt an approach of continuous improvement that combines the maintenance of resources, staff development, curriculum review and collaboration with industry. Monitoring the effectiveness of the activities implemented and gathering feedback from teachers, learners and businesses also helps institutions to identify opportunities for improvement and to adapt their training provision to the changing needs of the labour market.

Sustainability can therefore be understood as a continuous cycle, rather than a one-off action, in which each element reinforces the others and contributes to the long-term success of the implementation process.



Figure 2: Sustainable Implementation Cycle for Digital Manufacturing in VET Centres

7. Transferability to Other Manufacturing Sectors

7.1 Introduction

As part of Activity A3.1, the ShiftVET consortium explored the transferability of the project's digital fabrication approach beyond the wood and furniture sector. Three factsheets were developed by the participating VET centres, covering Electrical Installation, Industrial Automation and Electronics (JLCP), Mechatronics and Industry 4.0 (ASLAM), and Product Design/3D Forms (RMMT).

The purpose of this analysis was not to replicate the woodworking exercises directly in other fields, but to assess whether the technologies, learning methodology and digital competences developed through ShiftVET could be adapted to different vocational contexts.

The findings provide a consistent picture of the transfer potential of the ShiftVET approach and identify the main adaptations required in terms of applications, materials, equipment, safety and assessment.

7.2 Cross-sector Transferability Findings

The analysis conducted using the three factsheets from A3.1 confirmed a high level of transferability of the ShiftVET approach across all vocational training fields considered. Although the original exercises were developed for the wood and furniture sector, the digital manufacturing competencies involved are also relevant to electrical installation and automation, mechatronics, and product design.

A key conclusion is that transferability depends less on changing the educational methodology than on adapting its context of application. The basic workflow developed through ShiftVET, which combines digital design, scanning, prototyping or machining, testing, and refinement, remains applicable across all sectors. However, the objects produced, the materials used, the equipment, the safety requirements, and the assessment criteria must reflect the characteristics of each professional field.

Among the technologies analysed, 3D printing showed particularly high transfer potential, as it can be introduced with relatively minor adaptation and offers an accessible way to develop skills in prototyping and digital manufacturing. At the same time, the analysis highlighted the added educational value of combining technologies. Integrated workflows, such as scan → model → print/mill → test →

iterate, allow students to experience processes that closely resemble current Industry 4.0 practices.
Overall, the results suggest that the ShiftVET methodology can be understood as a cross-sectoral approach to digital manufacturing, rather than one limited exclusively to woodworking training.

7.3 Sector-Specific Transferability

VET field	Transfer potential	Most relevant technologies	Example of adaptation	Main considerations
Electrical Installation, Industrial Automation & Electronics	High	CNC, 3D scanning and 3D printing	Enclosures, DIN-rail mounts, panels or sensor housings	Insulating materials, electrical safety and functional requirements
Mechatronics / Industry 4.0	High	3D printing	Mechanical connectors, brackets and prototype components	CAD modelling, mechanical performance and prototype validation
Product Design / 3D Forms	High	3D printing and combined technologies	Handles, fittings, connectors and functional product components	Ergonomics, design quality, contextual adaptation and equipment availability

Table 1: Transferability of the ShiftVET approach to other VET fields

Despite the differences between the three vocational fields, the analysis shows a common pattern: the underlying digital competences remain largely transferable, while the practical application needs to be contextualised. This means that VET centres do not necessarily need to develop completely new learning methodologies when transferring ShiftVET activities; instead, they can adapt the existing exercises to sector-relevant products, materials and professional requirements.

7.4 Key Considerations for Transfer

Key consideration	Guidance for VET centres
Contextualise the activity	Maintain the learning objective but replace woodworking-specific products with components relevant to the target profession
Adapt materials	Select materials according to sector requirements, including mechanical, electrical, aesthetic or functional properties
Check equipment readiness	Assess available equipment before implementation and consider shared facilities, companies or makerspaces where necessary
Adapt safety requirements	Incorporate the specific safety and compliance requirements of the target sector
Align assessment criteria	Combine digital manufacturing competences with sector-specific criteria such as functionality, accuracy, safety, ergonomics or design quality
Support trainers	Provide examples and adaptation templates that help trainers contextualise activities without changing their underlying learning objectives

Table 2: Key considerations for transferability

These findings demonstrate that transferability should not be understood as the direct replication of the same exercise in another sector. Instead, successful transfer requires preserving the digital learning process while adapting the professional context. A furniture component may become a PLC enclosure, a mechanical bracket or a product-design prototype, while the underlying process of designing, manufacturing, testing and refining remains essentially the same.
This approach allows the ShiftVET methodology to be replicated across different VET environments while maintaining both its educational objectives and its relevance to the professional context in which it is applied.

8. Good Practices Examples

8.1 Introduction

The implementation of these technologies, as part of the ShiftVET project, provides valuable practical experience that can support other vocational training centres wishing to introduce similar approaches or activities. Beyond the technical aspects of the selected technologies, the pilot activities have demonstrated how digital tools can improve learner engagement, promote project-based learning and strengthen the link between vocational training and industry.

The following good practices present examples of how 3D printing, 3D scanning and CNC machining can help VET programmes to be modernised.

Rather than describing the technologies themselves, these examples focus on their educational application, the learning outcomes achieved and the practical lessons learnt during implementation. Taken together, they illustrate different approaches that can be adapted and replicated by other vocational training centres according to their own contexts and the resources available.

8.2 Good practices Identified during ShiftVET

Good practice	Description	Benefit for VET centres
Start with simple projects	Begin with introductory activities before moving to complex tasks	Builds students' confidence and reduces implementation barriers
Combine traditional and digital skills	Integrate digital technologies into existing woodworking projects rather than treating them as separate subjects	Facilitates curriculum integration and increases relevance
Promote project-based learning	Encourage students to work on practical challenges that combine design and manufacturing	Improves motivation and problem-solving skills
Foster collaboration	Organise teamwork and peer learning activities	Develops communication and collaborative competences

Maintain links with industry	Use examples inspired by real industrial applications and involve companies where possible	Ensures training remains aligned with labour market needs
Collect continuous feedback	Regularly gather feedback from teachers and students to refine activities	Supports continuous improvement and long-term sustainability

Table 3: Good practices of ShiftVET

The implementation of ShiftVET demonstrated that the successful integration of digital manufacturing technologies depends not only on the equipment available but also on appropriate planning, teacher preparation and active learning methodologies. The good practices identified during the project can be readily adapted by other VET centres wishing to introduce similar technologies into their own training programmes.

9. Step-by-Step Implementation Roadmap

The successful integration of digital manufacturing technologies into Vocational Education and Training is best achieved through a structured, progressive and well-planned implementation process. Drawing on the experience gained throughout the ShiftVET project, this roadmap outlines the key stages that VET centres should consider when planning, implementing and consolidating the adoption of technologies such as 3D printing, 3D scanning and CNC machining. Rather than presenting a fixed model, it offers a flexible framework that can support institutions at different stages of their digital transformation journey.

Although each VET centre operates within its own educational context, with varying levels of resources, expertise and infrastructure, following a clear sequence of actions can significantly facilitate implementation, reduce potential challenges and support informed decision-making throughout the process. By progressing step by step, from the initial assessment of institutional needs to the continuous evaluation and improvement of teaching practices, centres can introduce digital technologies in a sustainable and pedagogically meaningful way. The roadmap presented below therefore serves as a practical reference for institutions wishing to strengthen their digital manufacturing capacity. It can be adapted to different educational environments, organisational structures and levels of technological readiness, providing a clear pathway towards the successful and long-term integration of innovative manufacturing technologies into vocational education.

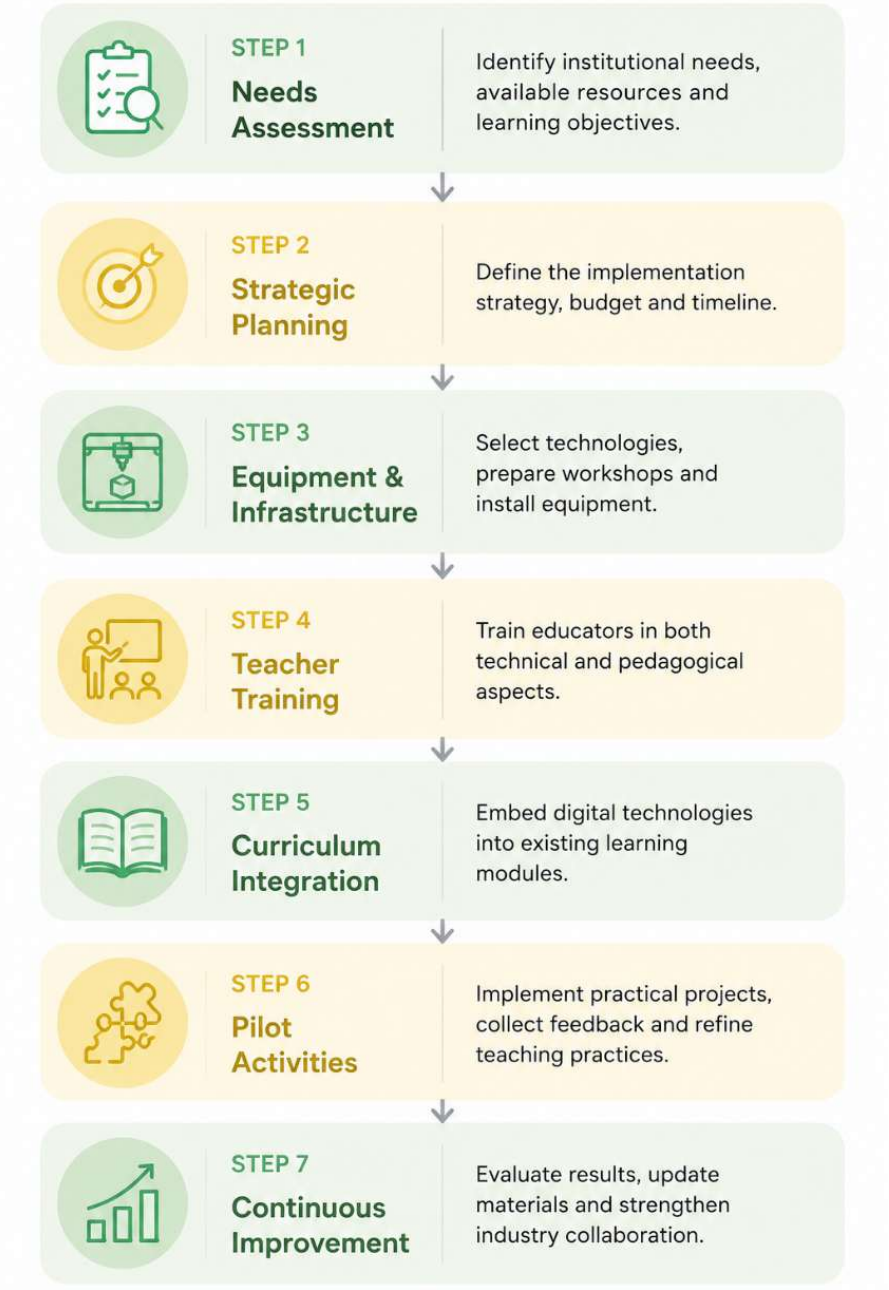


Figure 3: ShiftVET Roadmap

The roadmap should be understood as a continuous improvement process rather than a linear sequence of isolated actions. Regular evaluation, stakeholder engagement and curriculum updates ensure that digital manufacturing technologies remain relevant and continue to provide value to both learners and VET institutions.

10. Policy and Strategic Recommendations

The successful integration of digital manufacturing technologies into vocational education and training requires commitment from VET centres, but also from the educational policies that underpin them, as well as sound strategic planning. Projects such as ShiftVET demonstrate the feasibility and educational value of introducing technologies such as 3D printing, scanning and CNC into training programmes. Furthermore, their adoption also depends on the creation of favourable conditions at both the political and organisational levels. The recommendations set out below are based on the experience gained throughout the project and aim to support policymakers, education authorities, vocational training providers and other stakeholders.

10.1 Policy Recommendations

Recommendation	Purpose
Promote investment in digital infrastructure	Support VET centres in acquiring and maintaining modern manufacturing technologies
Encourage continuous professional development	Facilitate regular training opportunities for VET teachers in emerging digital technologies
Foster collaboration between education and industry	Strengthen partnerships to ensure curricula remain aligned with labour market needs
Support flexible curriculum development	Enable institutions to integrate new technologies without requiring complete curriculum redesign
Promote open educational resources	Encourage the sharing and reuse of training materials developed through publicly funded projects
Facilitate international cooperation	Promote exchange of good practices between VET providers across Europe

Table 4: Policy Recommendations

10.2 Strategic Recommendations

At an institutional level, VET centres should adopt a long-term strategy for digital transformation. For this to be successfully implemented, it is necessary to invest continuously in equipment, teacher training and curriculum innovation, as well as to carry out regular evaluations and collaborate with external stakeholders who may also be of assistance.

Digital manufacturing technologies should be progressively integrated into existing programmes, ensuring that they complement traditional vocational skills and also meet the needs of today's industry. Institutions, for their part, should also establish mechanisms for the ongoing review of teaching materials, monitor technological developments and encourage active participation in national and international cooperation initiatives.

Finally, it should also be emphasised that the long-term sustainability of initiatives such as this depends on maintaining collaboration between education providers, industry, public authorities and participating organisations. By working together, these parties can create a more resilient, innovative and forward-looking vocational training system, capable of preparing students for the sector's employment challenges.



Figure 4: Agents involved

11. Conclusions and Future Outlook

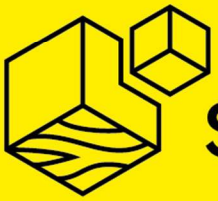
The ShiftVET Project has demonstrated that digital manufacturing technologies can be successfully integrated into vocational training when supported by appropriate educational resources, teacher training, practical activities and realistic planning. The use of tools such as 3D printing, 3D scanning and CNC machining helps learners develop technical and digital skills whilst enhancing problem-solving, teamwork and creativity. These technologies are most effective when used to complement, rather than replace, traditional vocational skills.

The implementation experience also shows that the success of digitalisation depends on more than just access to equipment. Equally important are sufficient time for practical activities, teacher training, progressive learning pathways, integration into the curriculum and the proper organisation of workshops. Feedback from trainers and learners confirms the relevance and feasibility of the ShiftVET approach, whilst also identifying practical challenges relating to software, equipment availability and prior experience levels.

Another noteworthy finding is the potential to transfer the project's approach beyond the wood and furniture sector. Activity A3.1 identifies a high level of transferability to courses such as 'electrical installation and automation', 'mechatronics' or 'product design'. The basic methodology of digital manufacturing can be retained whilst the products, materials, equipment, safety requirements and assessment criteria are adapted to each professional context.

Looking ahead, the digital transformation of vocational education and training (VET) must be understood as an ongoing process. Technologies and labour market needs will continue to evolve, meaning that VET centres will need to update their curricula, resources and practices, whilst maintaining close cooperation with industry and other stakeholders.

Therefore, the completion of ShiftVET should not be seen as the end of the implementation process, but rather as a starting point for further adaptation, replication and continuous improvement. The resources and lessons learnt generated by the project provide vocational education and training centres with a practical foundation to continue their digital transformation and prepare learners for manufacturing environments that are increasingly technology driven.



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