3D SCANNER TECHNOLOGY

SHIFTVET
Digital Transformation for Wood and Furniture VET

Content

SHIFTVET

Figures

SHIFTVET

Key terms

Point Cloud
A collection of millions of points in 3D space (X, Y, Z coordinates) that represent the surface of a scanned object.

Mesh / Polygon Mesh
A digital surface created from a point cloud, formed by connected polygons that represent the object's geometry.

Noise (in scanning)
Unwanted or inaccurate data points caused by reflections, poor lighting, or scanning errors.

STL (STereoLithography)
Common file format used to export scanned models for 3D printing or further processing.

OBJ (Object file format)
3D file format that can store geometry and, in some cases, texture information from scanned models.

CAD (Computer-Aided Design)
Software used to modify, analyse, or redesign scanned 3D models.

1. Introduction

1.1 ShiftVET Project Overview

The **ShiftVET** Project is designed to support initial Vocational Education and Training (i-VET) trainers in introducing digital technologies into carpentry teaching. Its aim is to help modernize current training programs so that students can develop the digital skills needed in the carpentry and manufacturing industries. By making learning more innovative and engaging, the project also aims to increase students' interest in these career paths.

To guide this transformation, **ShiftVET** focuses on four key objectives:

- Help trainers understand how digital technologies can be applied in carpentry VET and how they can improve teaching and learning.
- Create a free online repository of accessible materials, examples, and exercises that teachers can easily integrate into their classes.
- Evaluate practical digital tools, such as 3D scanner, with students to explore how these technologies can enhance hands-on learning.
- Encourage the use of advanced technologies not only among project partners but also in other vocational training centres while exploring how the tools could benefit other industries.

1.2 Purpose of this guide

The **aim of this guide** is to help VET training instructors in carpentry to introduce and integrate 3D scanning into their teaching practice. As digital technologies increasingly shape the carpentry and manufacturing sectors, 3D scanning has become a powerful tool for digitalization, analysis, documentation, design development, and creative problem solving. Understanding its potential is essential to preparing students to thrive in a modern, technology-enabled professional environment.

This guide has been specifically developed to help educators gain the knowledge, confidence, and practical skills necessary to effectively use 3D scanning technologies in woodworking instruction.

It offers a clear and accessible introduction to the fundamentals of 3D scanning and digital capture: what it is, how it works and why it is an important complement to traditional woodworking techniques and digital design tools.

More specifically, this guide aims to:

- Build a solid foundation on the principles of 3D scanning, including key concepts, types of scanners, accuracy considerations, data formats, and essential digital workflows.
- Clarify its relevance to woodworking, showing how 3D scanning can support activities such as reverse engineering, digital documentation of existing

pieces, quality control, restoration work, custom design development, and integration with CAD/CAM processes.
- Provide practical, classroom-ready strategies for incorporating 3D scanning into VET programs, including lesson ideas, hands-on exercises, data processing workflows, safety considerations, and tips for managing scanning equipment.
- Support trainers with varying levels of experience by offering clear explanations and concrete examples that make 3D scanning accessible even to those who are new to digital capture technologies.
- Strengthen the links between digital and traditional craftsmanship, helping students understand how 3D scanning can complement woodworking skills by translating physical objects into digital models, rather than replacing hands-on making processes.

The purpose of this guide is to make 3D scanning an accessible, inspiring, and educationally valuable resource for both trainers and students, helping them bridge the gap between traditional craftsmanship and the opportunities offered by digital technologies in contemporary carpentry and furniture making.

1.3 Who is the guide aimed at?

This guide is designed for vocational training instructors and educators in carpentry who wish to introduce 3D scanner into their teaching practice. It is aimed at professionals who may have varying levels of familiarity with digital technologies, from those who are just starting out to those who are more experienced and want to integrate it more effectively into their classes.

More specifically, this guide is aimed at:

- **Vocational training instructors in carpentry** are looking for practical tools, examples, and strategies for incorporating 3D scanner into their classrooms and workshops.
- **Vocational training providers and training centres** are interested in modernizing their curricula and offering students access to relevant digital technologies.
- **Educators in related technical or manufacturing fields** who want to understand how 3D scanner can complement traditional craftsmanship and enhance learning experiences.
- **Trainers in continuing professional development** want to strengthen their digital skills and expand their teaching resources.
- **Anyone involved in designing, coordinating, or supporting vocational training programs** that aim to promote innovation, creativity, and digital readiness among students.

1.4 How to use this guide?

This guide is designed as a practical and flexible resource to help trainers integrate 3D scanner into vocational training in carpentry.

You can use it progressively, returning to different sections as your understanding and confidence grow. There is no need to read it all at once; instead, it can accompany you throughout your teaching practice.

Here's how to get the most out of it:

1. **Start with the basics**- Begin by exploring the introductory chapters to understand what 3D scanner is, how it works, and why it is becoming increasingly relevant in woodworking. This foundation will help you connect technology with traditional training methods.
2. **Familiarize yourself with the tools and materials**- Review the sections describing the types of 3D scanner, common materials, software workflows, and essential terminology.
3. **Explore pedagogical applications**- The guide includes examples and explanations illustrating how 3D scanner can be applied in woodworking vocational training. These sections will help you visualize opportunities in the classroom.
4. **Use the hands-on activities**- You will find demonstrations for the classroom. These activities are designed to be flexible so they can be adapted to various levels.
5. **Experiment and reflection with your students**- Implementation is most effective when trainers and students explore the technology together. Use hands-on tasks to experiment, discuss results, solve problems, and encourage students to improve their designs.
6. **Use it as an ongoing reference**- The guide is not meant to be read once and set aside. It is a reference you can turn to whenever you need clarification, examples, or inspiration for designing new lessons. You can also combine them with the following resources that will be developed in the **ShiftVET** project.

2. Description of technology

2.1 What is 3D scanner?

3D scanning is the process of collecting data from the physical world to reconstruct it as a digital 3D model. This involves capturing the geometry of real objects so that they can be represented digitally, enabling applications such as measurement, inspection, or digital preservation.
The specific way in which 3D scanning is performed depends on the type of technology used and the type of data to be captured, but the main objective remains the same, which is to record the physical dimensions and surface information to convert it into a digital format.
The result of a 3D scan will therefore consist of high-resolution point cloud data or mesh models representing the shape and surface characteristics of the scanned object, which can then be used in software for analysis, design, or workflows [1].

Figure 1: 3D scanner [2].

2.2 How does 3D scanner work?

3D scanning is the process of capturing the physical dimensions of an object or environment to create a digital representation. This technology is revolutionizing the way we design, manufacture, and interact with the world, offering unprecedented levels of detail and precision. 3D scanners have become essential tools for quality control, product design, and other applications.
The ability of a 3D scanner to capture both geometry and texture is fundamental to its functionality. By recording a large number of data points on the surface of an object, these devices create highly detailed three-dimensional models. This digital conversion process is crucial for applications that require accurate measurements

and complex designs. The resulting models serve as versatile tools for virtual simulations, improving the efficiency and quality of processes.

General scanning workflow:
Although different 3D scanning systems use different measurement principles, they all follow a common operational workflow:

1. **Data captured from the object's surface:** The scanning system captures information from the surface of an object by recording how a projected signal or observed image interacts with that surface. This step focuses on collecting raw geometric data that describes the object's external shape.
2. **Distance and spatial measurement:** The scanner calculates the spatial position of multiple surface points by determining their distance relative to the scanner's sensors. These measurements are translated into three-dimensional coordinates (X, Y, Z), which describe the object's geometry in space.
3. **Point cloud generation**: The collected measurements are combined into a point cloud, which is a dense set of individual points representing the surface of the scanned object. Each point corresponds to a precise location in three-dimensional space and collectively defines the object's form.
4. **Alignment and data merging:** For complex objects, multiple scans are often required to capture all surfaces. Specialized software aligns and merges these separate datasets into a single, coherent point cloud, ensuring continuity and completeness of the digital model.
5. **Surface reconstruction and model creation:** The unified point cloud is processed to generate a surface model or polygon mesh, which represents the continuous geometry of the object. This model can be refined, cleaned, or optimized depending on its intended use.
6. **Export and use of the digital model:** The final 3D model can be exported in standard digital formats (such as STL or OBJ) and used for design, analysis, documentation, quality control, or integration with CAD and manufacturing workflows.

On the other hand, the role of the software in the scanning process is also critical. In 3D scanning software is important because it manages data capture, processing raw measurements, filtering noise, aligning multiple scans, and generating usable digital models. Without dedicated software, the raw data produced by the scanner cannot be transformed into meaningful or practical 3D representations [1], [3].

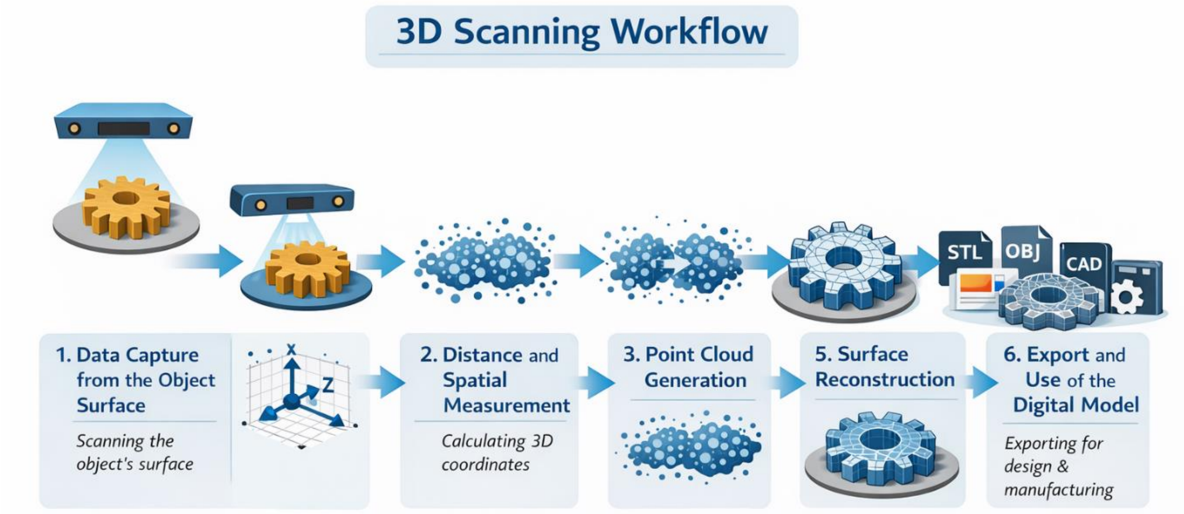

Figure 2: 3D Scanning workflow. Open IA (2026).

2.3 Types of 3D scanner technologies

Now that we have looked at this technology in general terms, we can focus on the diverse types that exist. There are five main categories of 3D scanner technologies, each with its own characteristics, advantages, and limitations.

2.3.1. 3D scanning by laser triangulation

This technology forms a triangle between the laser emitter, the measured object, and the sensor to calculate the position of millions of points on the surface. A point or line laser projects light onto the object, and sensors capture the reflection, allowing the system to calculate spatial data.

In this method, the scanner knows the position of the laser source, the position of the camera, and the angles and distances between them.

When the laser hits the object, the sensor captures the reflection at a specific angle. The system then uses simple geometric relationships (based on the triangle formed by these three elements) to calculate the coordinates of the point on the object's surface.

This scanning process usually works as follows:

1. A **laser line or dot** is projected onto the object.
2. A **camera or sensor** located at a known angle captures the reflected light.
3. Specialized software calculates the **precise location of each point** on the surface by applying triangulation formulas.
4. As the scanner moves, it collects many of these points to reconstruct the complete geometry of the object.

Why is this method useful?

- Exactly accurate and detailed, ideal for small or medium-sized objects
- Often used when accuracy is important, such as when measuring parts or details.

However, the main limitation is that shiny or transparent surfaces can cause problems as the laser does not reflect properly.

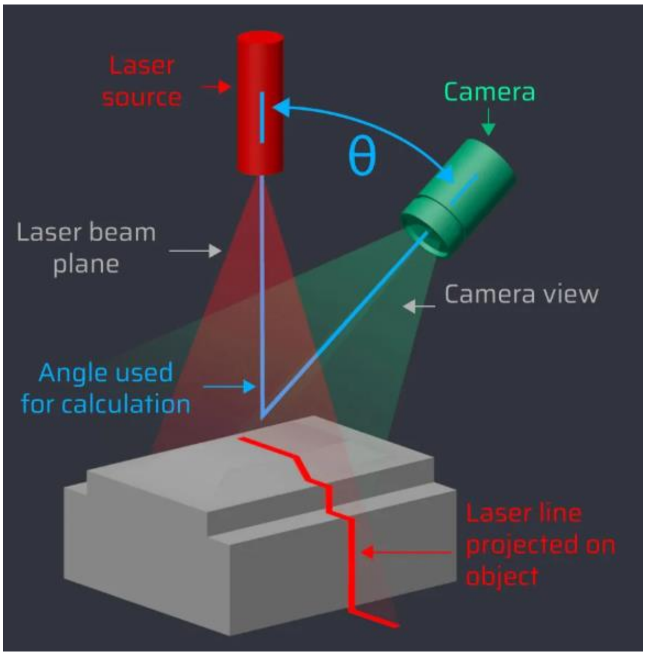

Figure 3: 3D scanner- Laser triangulation [4].

2.3.2. Structured light 3D scanning

Structured light scanning is a 3D scanning technology that works by projecting a known light pattern onto an object and analysing how this pattern changes when it hits the object's surface. By observing these deformations, the system can calculate the three-dimensional shape of the object.
Unlike laser scanning, structured light scanners typically project a series of light patterns (such as stripes or grids) onto a larger area. One or more cameras record how these patterns bend, stretch, or compress depending on the geometry of the surface.
The scanner software then compares the captured images and using geometric calculations, determines the exact position of each visible point on the surface and converts this information into 3D coordinates.
<u>How does the process work?</u>

1. A light pattern is projected onto the object.
2. Cameras observe how the pattern is distorted by the shape of the object.
3. The software analyses these distortions and calculates the position of the points on the surface in three dimensions.
4. Thousands or millions of points are captured at once, creating a detailed digital representation.

<u>Why is structured light scanning useful?</u>

- **Fast**, as it captures large areas of an object at once rather than point by point.
- **Accurate**, capable of capturing delicate details depending on the resolution of the scanner.
- **Safe and contactless**, as it uses visible or white light instead of lasers.

The <u>main limitations</u> to consider are:

- Structured light scanning is sensitive to **external lighting conditions**. Intense ambient light, direct sunlight, or reflections can interfere with the projected pattern and reduce scanning accuracy. For this reason, scanning is typically performed in controlled indoor environments.
- Very dark, shiny, or transparent surfaces may require prior preparation to ensure reliable pattern detection.

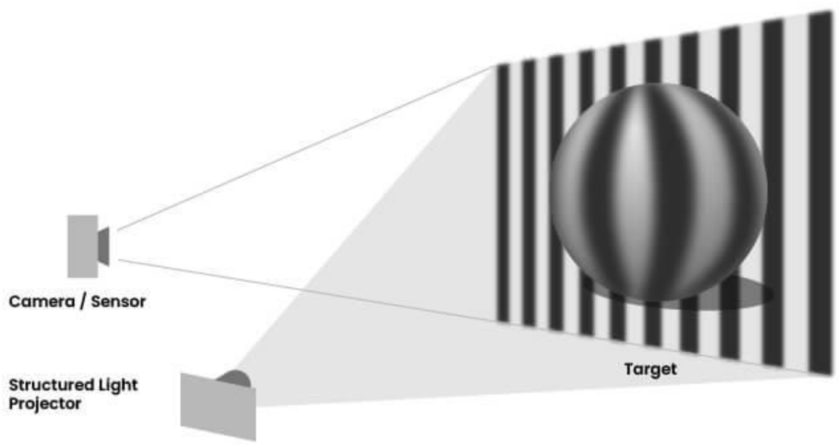

Figure 4: Structured Light 3D Scanner [5].

2.3.3. 3D scanning by photogrammetry or photo scanning

Photogrammetry is a way to create a 3D model of a real object using a series of photographs taken from different angles. Instead of using a specific scanner, it can often be done with a phone or digital camera, making this method accessible and affordable.

How does photogrammetry work?

1. Take lots of photos of the object: walk around it and take photos every few degrees to capture all sides.
2. A computer program analyses all the images for special reference points that appear in more than one photo.
3. By comparing those reference points in different photos, the software determines where each point is in space and uses that information to build a 3D model.
4. The result is a digital 3D representation of the object that can be viewed, measured, or exported to other software.

In other words:

- The software looks for features that appear in multiple photos.
- It calculates their position in 3D.
- These positions form the basis of the 3D model.

Why is this a **useful** method?

Photogrammetry offers several practical advantages that make it attractive for education and workshops:

- Low cost: No special scanners are needed; a normal camera or phone camera is sufficient.
- Flexible: It works with a wide range of objects, including irregular shapes or textured surfaces.
- Portable: It can be used outside the classroom or in the workshop without the need for special setup.

This makes photogrammetry an excellent **basic way to teach 3D capture** without the need for a large investment in hardware.

What are the main **limitations**?

- **Good lighting is important**: if the photos are too dark or have strong shadows, the software may have difficulty finding matching points.
- **Many photos are needed:** the more photos taken from different viewpoints, the better the result. A few photos will not produce an accurate model.
- **Processing time:** creating the 3D model from photos can take time on a computer, especially if many high-resolution images are used.

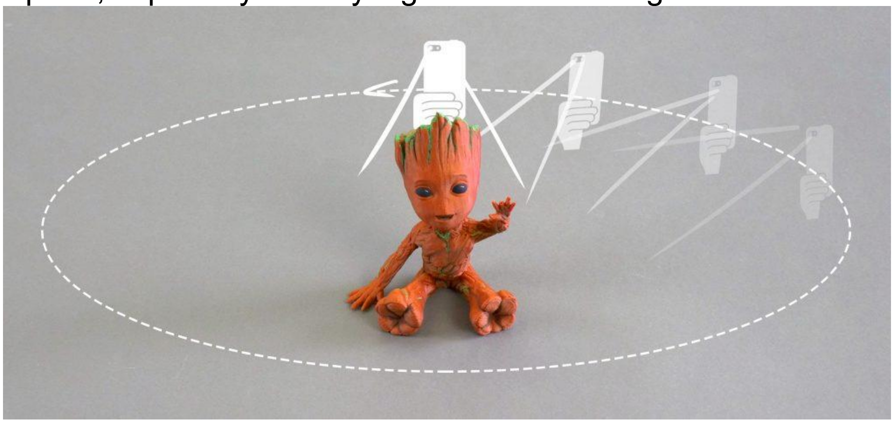

Figure 5: Photogrammetry [6].

2.3.4. Contact 3D scanning

Contact 3D scanning is a method in which the shape of an object is captured by physically touching its surface with a probe. Instead of using lasers or light, this type of scanner measures the object point by point through direct contact. This makes it quite different from most modern optical scanners.

How does it work?

1. A small probe or tip touches the surface of the object.
2. Each time the probe touches the object, the system records the exact position of that point in space.
3. The probe moves along the object, either manually or using a mechanical arm.
4. All the measured points are combined to build a digital 3D model of the object's surface.

Since the probe physically touches the object, the scanner always knows exactly where the surface is, without being affected by light, colour, or reflections.

What are the advantages?

Contact scanning is especially valuable in situations where high accuracy is required. This method offers:

- Extremely high accuracy, making it suitable for measurement and inspection tasks.
- Reliable results even with transparent, shiny, or very dark materials, which are often difficult for optical scanners.
- Stable and repeatable measurements, which is important in quality control.

For these reasons, contact scanning is commonly used in industrial inspection and quality verification, where accuracy is more important than speed.

It is also important to keep these limitations in mind:

- **Slow process:** Each point must be touched individually, so scanning large or complex objects takes a long time.
- **Limited flexibility:** Objects with deep cavities, complex curves, or fragile surfaces can be difficult or impossible to scan.
- **Physical contact**: Since the probe touches the object, this method is not suitable for soft, flexible, or delicate materials that could be damaged.

For these reasons, contact scanning is less common in classrooms or workshops and is usually reserved for specialized measurement tasks.

Figure 6: Contact 3D scanning [7].

2.3.5. Laser pulse-based 3D scanning

This type of 3D scanning is a scanning method that measures objects by sending out short laser pulses and measuring the time it takes for them to return after hitting a surface. By knowing the speed at which light travels, the system can calculate the distance to the object with great precision.
In simpler terms, the scanner:

- sends out a laser pulse,
- waits for the reflection to return,
- measures the time it took.

- and converts that time into distance.

How does this type of scanning work?

1. **1.** The scanner emits a laser pulse toward the object or environment.
2. **2.** The laser hits the surface and bounces back to the scanner.
3. **3.** The system measures the time between the emission and return of the pulse.
4. **4.** From this time, the scanner calculates the distance to that point.
5. **5.** This process is repeated many times per second to build a 3D representation of the object or space.

Why is it useful?

Pulse laser scanning is especially useful when:

- The object or area is exceptionally large, such as buildings, rooms, machinery, or outdoor structures.
- It is necessary to capture the general shape and dimensions, rather than the excellent details of the surface.
- The scanner must operate at great distances from the object.

For this reason, this technology is commonly used in fields such as architecture, construction, industrial facilities, and large-scale inspection.

Limitations to consider are:

- It is slower than other optical scanning methods, as each distance measurement relies on the timing of laser pulses.
- The level of detail is usually lower than that achieved with laser triangulation or structured light scanners.
- The equipment is usually larger and more expensive, making it less suitable for classroom or workshop environments [4], [8].

Figure 7: Laser pulse-based 3D scanning [9].

2.4 General applications

3D scanning is a technology that captures the shape of real objects and creates a digital 3D model that can be used in many ways:

- **Digitization and documentation**

3D scanners are used to digitize objects and environments, converting physical shapes into digital files. This allows you to:
  - Record and store objects digitally.
  - View and share models on a computer.
  - Keep digital records for future use or reference.

This is extremely useful when objects are too large, fragile, or difficult to move, or when a permanent record is needed.

- **Design and development**

Once an object has been scanned, the digital model can be used with design software such as CAD. This allows you to:
  - Modify or improve existing designs.
  - Create new parts based on the scanned object.
  - Combine scanned models with new digital elements.

This application can speed up product development and assist with design tasks when the original design files are not available.

- **Reverse engineering**

3D scanning is often used to recreate a digital model of an object when no CAD or original blueprint exists. This process is known as reverse engineering.
In practice:
  - The object is scanned.
  - A digital model is created from that scan.
  - The model can be used to reproduce or adapt the object.

This is especially useful in workshops, manufacturing, and repair tasks.

- **Inspection and quality control**

By scanning a part or object and comparing the digital model to the expected measurements, users can:
  - Check if the object meets design specifications.
  - Detect differences in shape or size.
  - Verify that parts are manufactured correctly.

This makes 3D scanning a valuable tool when accurate measurement or verification is required.

- **Integration with other digital tools**

3D scanners work well with other technologies. For example:
  - Models can be exported for 3D printing or CNC machining.
  - Digital files can be used in design or simulation software.
  - They can support workflows that combine physical and digital processes.

This means that 3D scanning is not independent but can be part of a broader digital workflow [10].

When 3D scanning is not the best solution

Although 3D scanning is a powerful digital tool, it is important to understand that it is not always the most suitable solution for every task. In some situations, traditional methods or other digital tools may be more efficient or appropriate.
3D scanning may not be the best option when the object has very simple geometry that can be measured quickly with manual tools or designed directly in CAD. In these cases, scanning can add unnecessary steps to the workflow.
It is also less effective when objects are very small, highly reflective, transparent, or made of materials that are difficult to capture accurately without surface preparation. In educational environments, limited time, insufficient lighting control, or lack of suitable equipment can also reduce the quality of results.
Helping students understand when *not* to use 3D scanning supports critical thinking and encourages informed decision-making when selecting digital technologies.

2.5 Required equipment

To perform a 3D scan, a **small set of basic equipment** is required. The exact configuration depends on the type of scanner used, but most 3D scanning setups share the same essential elements.

- **3D scanner**

The most essential element is the 3D scanner itself.
It is a device that captures the shape of the object. Depending on the technology, the scanner may:

- use light or lasers
- be portable or fixed on a tripod
- scan small objects or larger surfaces

The scanner is responsible for collecting the raw data that will later be converted into a digital 3D model.

- **Computer (PC or laptop)**

A computer is needed to:

- control the scanner
- view the scanning process
- process the captured data

The computer must be powerful enough to handle 3D data, especially when working with detailed scans or large objects. In most cases, a modern standard laptop or desktop computer is sufficient for educational use.

- **3D scanning software**

3D scanning software is necessary for:

- capturing data from the scanner
- aligning different scans
- creating the final 3D model

This software usually comes included with the scanner and offers a guided, easy-to-use interface. Without this software, the data captured by the scanner cannot be converted into a usable 3D model.

- **Stable work surface**

It is important to have a stable table or workbench to ensure that:

- the object does not move during scanning
- the results are consistent and reliable

For small objects, a simple table is sufficient. For larger objects, a clear and stable surface is required.

- **Turntable (optional but useful)**

A turntable is often used to scan small or medium-sized objects.
It allows the object to:

- rotate smoothly
- be scanned from all sides without moving the scanner

This makes scanning easier, faster, and more consistent, especially for beginners.

- **Markers or reference points (optional)**

Some scanning systems use small adhesive markers placed on or around the object.
These markers help the software to:

- recognize different scanning positions
- correctly align multiple scans

They are especially useful when scanning objects with little detail on the surface

- **Power supply and cables**

The scanner and computer require:

- a reliable power supply
- suitable connection cables (USB or similar)

Ensuring a stable power supply and correct connections prevents interruptions during scanning.

- **Simple environmental requirements**

The importance of the scanning environment should also be noted:

- Indoor spaces are preferred
- Controlled lighting helps improve results
- Avoid bright sunlight or reflections [1].

2.6 Technical Setup Checklist

Before starting any classroom activity with a 3D scanner, it is essential to make sure that the equipment is properly set up and safe to use. The following checklist summarizes the key technical elements that teachers should verify before starting the scanning process.
Use it as a quick-reference tool to ensure reliability, safety, and smooth operation of the scanning activity.

Equipment readiness

- ☐ The 3D scanner is installed or positioned on a stable surface and cannot move accidentally during scanning.
- ☐ The scanning area is clean, tidy, and free of obstacles that could interfere with the scanning process.

- The scanner is properly connected to the computer (USB, power supply, or wireless connection if applicable).
- The scanner has been calibrated, if required by the manufacturer, following the recommended procedure.
- The computer meets the minimum technical requirements to run the scanning software smoothly.
- The 3D scanning software is installed, updated and working correctly.
- If a turntable is used, it is stable and rotates smoothly.
- If reference markers are required, they are available and correctly placed on or around the object.
- The object to be scanned is clean, dry, and stable, and will not move during scanning.
- The object fits within the recommended size range of the scanner.

Environment and scanning conditions

- The scanning activity is conducted indoors, in a controlled environment.
- Lighting conditions are appropriate for scanning (no direct sunlight or strong reflections).
- Highly reflective, transparent, or very dark surfaces have been identified, and surface preparation is considered if necessary.
- There is enough space around the object to move the scanner freely (for handheld scanners).

Safety checks

- Students have been informed that scanners use light or lasers and should not be pointed at eyes.
- Clear instructions are given on where students can place their hands during scanning.
- Cables are organized to avoid tripping hazards.
- The scanner and computer are used according to the manufacturer’s safety guidelines.
- The object being scanned does not present sharp edges or unstable parts.

Digital resources

- You have access to basic 3D viewing or editing software to check the scanned model.
- File formats for export (such as STL or OBJ) are known and understood.
- Enough storage space is available for scan data and point clouds.
- Students know where scanned files will be saved and how they will be used later (viewing, editing, printing, etc.).

Final check before scanning

- A short test scan has been performed to verify that settings and conditions are correct.

- Students understand the basic goal of the scanning activity and what the expected result should look like.

3. Potential of technology in woodworking VET

3.1 Educational benefits

The integration of 3D scanning into vocational training in woodworking offers educational advantages when used as a tool to support practical learning. According to some classroom experiences described in the master's thesis *"Activities for bringing 3D scanning into the classroom,"* 3D scanning contributes positively to student participation, skill development, and learning outcomes.

- **Greater motivation thanks to working with real objects:**

In woodworking vocational training, students feel motivated when working with physical materials and real pieces. 3D scanning activities increase motivation because students interact directly with objects rather than just working with abstract concepts or drawings.

Thanks to this technology, students can scan wood joints, components, or tools they are already familiar with, which helps reduce resistance to digital tools in traditionally manual disciplines.

- **Improved spatial understanding of wood elements:**

Spatial visualization is another key benefit of 3D scanning in the classroom and can be particularly useful for vocational woodworking training as it helps students understand shapes, volumes, and joints. Through 3D scanning, students can observe joints from any angle, understand how pieces fit together, and even analyse some more complex shapes that are difficult to understand in 2D. This facilitates the transition from physical work to technical drawings and digital models.

- **Learning through practice and error analysis:**

Scanning activities also promote active learning, where students can test, observe results, and analyse errors that arise. In woodworking vocational training, this approach fits well as students can use technology to scan pieces of wood, detect inaccuracies or missing areas, and then discuss why the scan failed and how to improve it.

This process reinforces critical thinking skills and critical thinking, both of which are essential for those working in the woodworking sector.

- **Development of digital skills linked to craftsmanship:**

3D scanning in the classroom also improves students' digital skills, especially when accessible tools and software are used. In vocational woodworking training, this helps students connect traditional skills with modern digital work.

As a result, students learn to use digital tools responsibly, manage 3D files, and understand how physical objects can be digitized.

This prepares students for the increasingly common modern carpentry environments.

- **Communication and documentation skills:**

Students improve their oral and written communication skills by explaining their scanning process and the results obtained. In vocational training in carpentry, this reinforces professional skills such as documenting work, explaining technical decisions, and presenting results.
Students can write down how a piece was scanned, justify scanning decisions, and present improvements to designs.
These skills are directly transferable to real-world professional contexts.

- **Cooperative learning in workshop-based activities:**

The value of group work in scanning activities is particularly important, and 3D scanning also encourages these characteristics. In carpentry training, teamwork is already commonplace in workshop tasks, making 3D scanning a natural extension of collaborative learning.
Working in small groups encourages shared responsibility, improves communication, and reflects the real dynamics of the workshop.
This reinforces both technical and social skills [11].

3.2 Technical advantages of 3D scanner in Vocational Training for woodworking and carpentry

3D scanning offers several technical advantages that are particularly relevant to woodworking, as it allows real wooden objects to be accurately captured and transformed into usable digital models. This capability helps to connect traditional woodworking skills with the modern digital tools used in workshops.
One of the main technical advantages of 3D scanning is its ability to capture the exact shape and dimensions of wooden objects. Unlike manual measurement methods, which can be slow and prone to small errors, 3D scanning records the complete geometry of a piece, including curves, angles, and irregular surfaces. This level of accuracy is especially useful when working with complex wooden components, joints, or handcrafted pieces.
Another advantage is the ability to work with complex shapes that are difficult to measure by hand. Many woodworking projects include organic shapes, decorative elements, or custom details that are difficult to document with traditional tools. 3D scanning simplifies this process by capturing the entire surface of the object in a single digital model, which can then be examined from any angle.
Digital models generated through scanning can be easily used in design and modification processes. Once a wooden object has been scanned, the model can be opened in CAD software to adjust dimensions, improve designs, or adapt existing pieces to new requirements.
In addition, 3D scanning is also compatible with reverse engineering, which is the process of recreating a digital model from an existing physical object. In woodworking training, this is useful when the original plans or drawings are not

available, for example, when reproducing antique furniture pieces or adapting existing elements. Students can scan the object and use the digital model as a reference for reproduction or improvement.

3D scanning also helps save time during documentation and preparation. Capturing a piece digitally is often faster than measuring and drawing it manually, especially for complex objects. This efficiency allows students to spend more time analysing designs, understanding construction principles, and focusing on craftsmanship.

Finally, 3D scanning creates a strong link between physical work in the workshop and digital manufacturing technologies. Scanned models can be shared, stored, reused, or combined with other digital tools, such as CNC machines or 3D printers. In the case of vocational training in carpentry, this helps students become familiar with digital workflows, which are increasingly present in professional environments, while still valuing traditional manual skills [12].

Figure 8: 3D scanning of a figure [13].

3.3 Pedagogical checklist

Introducing 3D scanner in VET woodworking is not only a technical task, but also a pedagogical opportunity. Before designing classroom activities, teachers should verify that learning objectives, student readiness and curriculum alignment are clear.

This checklist helps ensure that 3D scanner is used in a meaningful, motivating and educationally effective way.

Learning goals

- ☐ The activity is clearly aligned with the woodworking and carpentry curriculum (joints, components, furniture, tools, restoration, etc.).
- ☐ Students understand the difference between physical objects and digital 3D models.
- ☐ Students understand the basic relationship between 3D scanning and CAD (scanning captures reality; CAD modifies or redesigns it).

- The task reinforces critical thinking, such as identifying scanning errors, missing areas or inaccuracies and discussing how to improve them.
- The activity includes hands-on interaction with real wooden objects before and after scanning.

Pedagogical preparation

- You have prepared a real wooden object to be scanned (joint, component, tool, small furniture element).
- You have an example of a completed 3D scan to show students what a successful result looks like.
- You have identified common scanning issues students may encounter (missing surfaces, noise, misalignment, reflections).
- You have prepared guiding questions, such as:
  - Why are some areas missing in the scan?
  - What caused this surface to be unclear?
  - How could we improve the scan next time?
- You have planned moments for peer collaboration, discussion, and comparison of results between groups.

Material adaptation for woodworking

- The scanned object is clearly connected to real woodworking processes (joints, fittings, decorative elements, templates, tools).
- Students can compare the physical wooden piece with its digital scan, identifying similarities and differences.
- The activity helps students understand how scanning supports woodworking, for example for documentation, analysis, or adaptation.
- Clear examples are provided to show that 3D scanning complements craftsmanship rather than replaces it.

3.4 Example of activities for woodworking VET

The following activities show simple and realistic ways to integrate 3D scanning into woodworking and carpentry VET. Each activity is designed to support hands-on learning and connect digital tools with traditional workshop practice.

Short project- Beginner level (1–2 sessions): Scanning and analysing a simple woodworking component

Objective: Introduce students to the 3D scanning workflow using a simple and familiar wooden object from the workshop.

- Description: Students select a small woodworking element such as a wooden joint sample, a spacer block, a handle, or a simple tool. They scan the object, generate a digital 3D model, and visualize it on the computer.

The class discusses scan quality, missing areas, and overall accuracy by comparing the digital model with the real object.
- Learning outcomes: Understand the basic 3D scanning workflow; Learn the difference between physical objects and digital models; Observe surface quality, geometry, and scanning limitations.
- Variation: Students scan the same object using different scanning angles or settings and compare the results.

Medium project- Intermediate level (3–4 sessions): Analysing and improving a woodworking joint through 3D scanning

Objective: Explore traditional joinery by digitally analysing a real wooden joint.
- Description: Students scan an existing wooden joint (e.g. dovetail, finger joint, mortise and tenon). The digital model is used to observe geometry, angles and fit. Students identify imperfections or inaccuracies and discuss how the joint could be improved before being recreated or adjusted in wood.
- Learning outcomes: Improve spatial understanding of joints; Learn to analyse geometry and tolerances; Connect scanning results with real woodworking precision.
- Variation: Diverse groups scan different joints and present which design offers the best fit or structural behaviour.

Longer project- Advanced level (1–2 weeks): Hybrid workflow – from scanned object to redesigned wooden piece

Objective: Understand how 3D scanning supports documentation, redesign, and adaptation in woodworking projects.
- Description: Students scan an existing wooden object or component (e.g. furniture detail, handle, decorative element, or tool). The scanned model is used as a reference to redesign or adapt the object (scale, proportions, or geometry). The definitive version is then produced or modified in wood.
- Learning outcomes: Understand the complementary role of 3D scanning in craftsmanship;
  Learn how digital capture supports redesign and planning; Apply both digital analysis and traditional woodworking skills.
- Variation: Students document the full process (object selection- scanning - analysis- redesign- woodworking outcome) and present their conclusions.

4. Integration in the classroom

4.1 Methodological recommendations

To successfully integrate 3D scanning into woodworking and carpentry VET, it is important to focus not only on the technology itself, but also on how it is introduced and used pedagogically. The following methodological recommendations help ensure that 3D scanning supports learning objectives and workshop practice rather than becoming an isolated or overly technical activity.

- **Start from real workshop objects**

3D scanning should be introduced using real wooden objects that students already know, such as joints, tools, components, or templates. Starting from familiar materials helps students understand the purpose of technology and reduces resistance to digital tools.
This approach aligns with recommendations for technology-enhanced vocational learning, where digital tools are most effective when connected to existing practical skills.

- **Keep the focus on learning goals, not on the tool**

The scanner should be presented to support learning, not as the main objective of the lesson. Teachers are encouraged to clearly explain why scanning is used in a specific activity (analysis, documentation, improvement, comparison).
Educational studies on 3D scanning highlight that learning outcomes improve when technology is used to solve concrete problems rather than as a stand-alone novelty.

- **Use a step-by-step and guided approach**

For non-expert learners, scanning activities should be introduced gradually:

  - first observing a demonstration,
  - then performing guided scanning,
  - and finally working more independently.

This scaffolding approach is recommended in technology-supported vocational education to avoid cognitive overload.

- **Encourage observation, comparison and discussion**

3D scanning naturally generates opportunities for discussion:

  - Why are some areas missing?
  - Why does one scan look better than another?
  - What could be improved?

Research on active learning shows that reflection and peer discussion significantly enhance understanding when collaborating with digital models.

- **Integrate scanning with traditional woodworking activities**

Scanning activities should be combined with hands-on workshop tasks, such as measuring, cutting, assembling, or finishing. This reinforces the idea that digital tools complement craftsmanship rather than replace it.

This hybrid approach is highlighted as best practice in modern vocational and technical education.

- **Adapt complexity to student level**

Not all students need to master advanced scanning settings or software. For beginner levels, basic scanning and visualization is sufficient. More advanced analysis can be introduced progressively.
Educational sources emphasize adapting digital tool complexity to learner readiness to maintain motivation and confidence.

- **Use scanning as a collaborative activity**

Whenever possible, scanning tasks should be carried out in small groups, with clear roles (scanner operator, observer, file manager, presenter). Collaborative work reflects real workshop dynamics and improves engagement.
Collaborative learning with digital tools is strongly recommended in vocational education contexts [14], [15], [16].

4.2 Step-by-step implementation plan

Step 1- Prepare the environment and equipment
Before starting to use 3D scanning, it is important to prepare a clean, stable, and well-organized space. The scanner must be correctly connected to the computer and the software installed and working properly.
It is recommended to carry out simple test scans with small wooden objects to check that the scanner captures the object correctly and that the digital model is visible and complete.

Step 2- Introduce the technology and its purpose
The teacher explains, in simple terms, what 3D scanning is and why it is useful in woodworking. The focus should be on its practical value: analysing shapes, documenting pieces, or supporting design improvements.
This step helps students understand that scanning is a support tool, not a replacement for manual skills.
Step 3- Demonstrate the scanning process
The teacher performs a live demonstration by scanning a simple wooden object. Each step is explained calmly, without technical overload, so students can observe the full workflow from object to digital model.
At this stage, students watch and ask questions.

Step 4- Guided student practice
Students work in small groups to scan a simple object under teacher supervision. Clear roles can be assigned (scanner operator, observer, file manager).
The objective is to let students gain confidence through guided hands-on experience, without focusing on perfection.

Step 5- Observe and analyse results

Once the scans are completed, students compare the digital model with the wooden object. Together, they identify missing areas, distortions or inaccuracies and discuss probable causes.
This step encourages observation, reflection, and critical thinking.

Step 6- Connect scanning with woodworking practice
The teacher links the scanning results to real workshop activities, such as understanding joint geometry, checking dimensions, or documenting pieces.
Students see how scanning can support traditional woodworking tasks in a practical way.

Step 7- Consolidate learning
Students summarize what they have learned and discuss how scanning could be used in future projects. This can be done through short discussions or simple written reflections.
This last step helps consolidate knowledge and prepares students for more advanced uses.

4.3 Classroom Integration Checklist

Once teachers are ready to integrate 3D scanner into their lessons, this checklist provides an at-a-glance guide to preparing, running, and closing a classroom activity. It ensures that all necessary materials, tools, digital resources, and pedagogical steps are ready, helping instructors manage the session smoothly and safely.

Preparation for the session

- ☐ You have selected a simple and suitable wooden object for scanning (joint sample, small component, tool, template).
- ☐ The object is clean, dry, and stable, and suitable for the scanner's size and capabilities.
- ☐ The scanner and computer have been tested beforehand to avoid technical issues during class.
- ☐ The scanning software is installed, updated and functioning correctly.
- ☐ You have a realistic time estimate for scanning and basic model viewing within one class session.
- ☐ Students have access to basic 3D viewing or editing software, appropriate to their level.

Materials and tools

- ☐ 3D scanner and power/data cables are available and in good condition.
- ☐ Computer or laptop with sufficient performance for scanning tasks.
- ☐ Turntable or reference markers are available if required by the scanner.
- ☐ Storage space (local or cloud) is prepared for saving scan files.

- The scanning area is organized and free of obstacles.

During the activity

- Students know their roles (scanner operator, object handler, observer, file manager, documenter).
- Students understand the basic scanning steps:
  - positioning the object,
  - capturing the scan,
  - checking scan completeness,
  - saving the file.
- A clear workflow has been explained: Object- Scan- Review- Analyse
- Time has been planned for observing and discussing scan quality (missing areas, noise, distortions).
- Safety rules have been explained (no pointing scanner at eyes, careful handling of equipment).

After the activity

- Students document the results (screenshots, photos of the object, short notes).
- A short reflection activity is prepared, for example:
  - What worked well during scanning?
  - What problems appeared?
  - How could the scan be improved?
- Scanned files are correctly saved and named for future use.
- The scanner and workspace are cleaned and prepared for the next group.

4.4 Tips for teachers

Below are some recommendations regarding 3D scanner for educational applications.

Recommendation	Description
Technical support and reliability	Before introducing a 3D scanner in the classroom, it is important to choose equipment that is dependable, easy to maintain and supported by the supplier.
Safety awareness	Teachers should understand and clearly communicate basic safety rules when using 3D scanning equipment. Students must know how to handle the scanner responsibly and follow instructions.
Appropriate scanning environment	The scanning area should be organized, stable and suitable for classroom use. A controlled indoor environment helps improve scan quality and makes activities easier to manage during lessons.

Choice of scanning technology	Different 3D scanning systems offer various levels of complexity. For educational use, it is recommended to prioritize ease of use and learning value rather than advanced technical features, ensuring the technology fits the classroom context and student level.
Start with simple learning tasks	Initial activities should focus on simple objects and clear learning goals. Starting small allows students to understand the scanning process step by step and gain confidence before moving on to more complex tasks.
Learning through observation and errors	Imperfect scans are part of the learning process. Teachers are encouraged to use scanning errors as opportunities for discussion and reflection, helping students understand limitations and improve their results.
Integration with practical activities	3D scanning should be integrated into hands-on workshop activities, reinforcing existing practical skills. This helps students see digital tools as a complement to traditional craftsmanship rather than a replacement [17].

5. Safety and sustainability in 3D scanner

When using 3D scanners in woodworking and carpentry VET, it is important to consider both basic safety aspects and the sustainable use of equipment and resources. According to guidance on educational use of 3D scanning, these aspects can be managed easily with clear rules and good classroom organization.

Safety considerations

3D scanners are safe to use in educational environments, as they do not involve hot surfaces or moving mechanical parts. However, teachers should ensure that students follow some basic rules:

- Scanners should never be pointed at the eyes, especially in systems that use light projection or lasers.
- Equipment must be managed carefully to avoid drops or impacts.
- Cables and connections should be organized to prevent tripping hazards.

Clear instructions and supervision help ensure safe use, especially when multiple students work with the scanner.

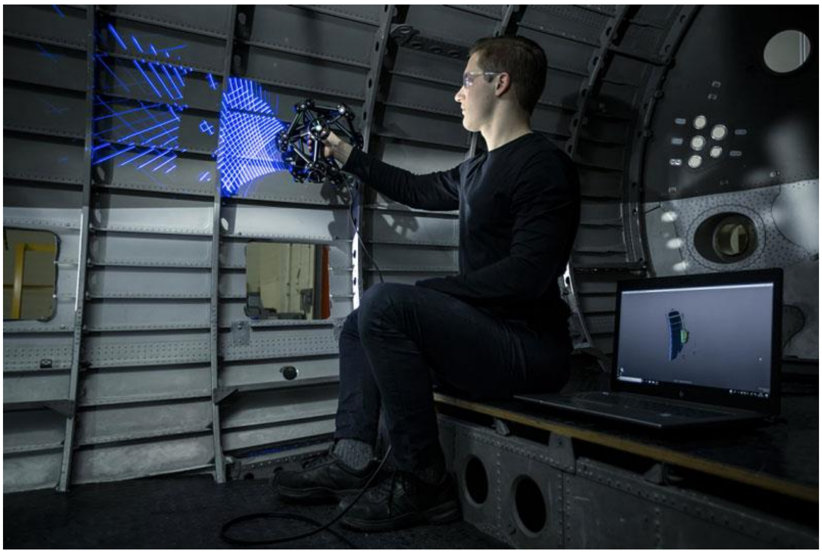

Figure 9: Person using a 3D scanner [18].

Sustainability considerations

From a sustainability perspective, 3D scanning supports efficient and responsible use of materials. By analysing objects digitally before making changes or reproducing parts, students can:

- Reduce unnecessary material waste.
- Avoid trial-and-error in wood.
- Improve planning before workshop work begins.

In addition, digital models can be stored, reused, and shared, reducing the need to repeatedly produce physical samples. This encourages a more sustainable approach to learning and production [17].

6. Additional resources

Title: Getting Started with the 3D Scanner

Author: Concord Free Public Library

Description: This is an introductory video about 3D scanner technology, showing the basics of how to start using this technology.

Link: https://www.youtube.com/watch?v=uqPB2PcHN-8

Title: How to scan a wooden chair | Calibry 3D scanner

Author: Calibry

Description: In this video, we can also see how the 3D scanner is used, a brief introduction, but focused on a wooden object, a chair.

Link: https://www.youtube.com/watch?v=I3qPHkGWRSA

Title: An introduction to 3d scanning

Author: CREAFORM

Description: This document provides a more visual introduction to 3D scanning technology.

Link: https://www.creaform3d.com/-/media/project/oneweb/oneweb/creaform3d/technical-documentation/ebook1_an_introduction_to_3d_scanning.pdf?la=en&revision=74cdebf2-5279-4a66-9b0e-3d16633ca6b4&hash=0C0545C976BB275A3830C5DD195FBA2C

Title: Calibry 3D scanner- User manual

Author: Calibry 3D scanner

Description: Manual on how to use this 3D scanning machine (Structured-light 3D scanner).

Link: https://thor3dscanner.com/assets/apps/support/Calibry_3D_scanner_Manual_ENG_OK.pdf

7. Conclusion

3D scanning is a valuable and accessible technology that can enrich woodworking and carpentry VET when it is used with clear educational objectives. By allowing wooden objects to be captured and analysed digitally, it helps students better understand shapes, joints and construction details while strengthening the link between manual craftsmanship and digital tools. In line with the **ShiftVET** project, this guide supports the gradual integration of digital technologies into vocational training, helping teachers modernize their teaching practices while keeping a strong connection to workshop reality. With simple preparation, clear safety rules and realistic activities, 3D scanning can be introduced smoothly into the classroom. Used in this way, it becomes a practical support tool that prepares learners for evolving professional environments while respecting the value of traditional woodworking skills.

From wood to digital→ understanding craftsmanship through 3D scanning!

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Co-funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.