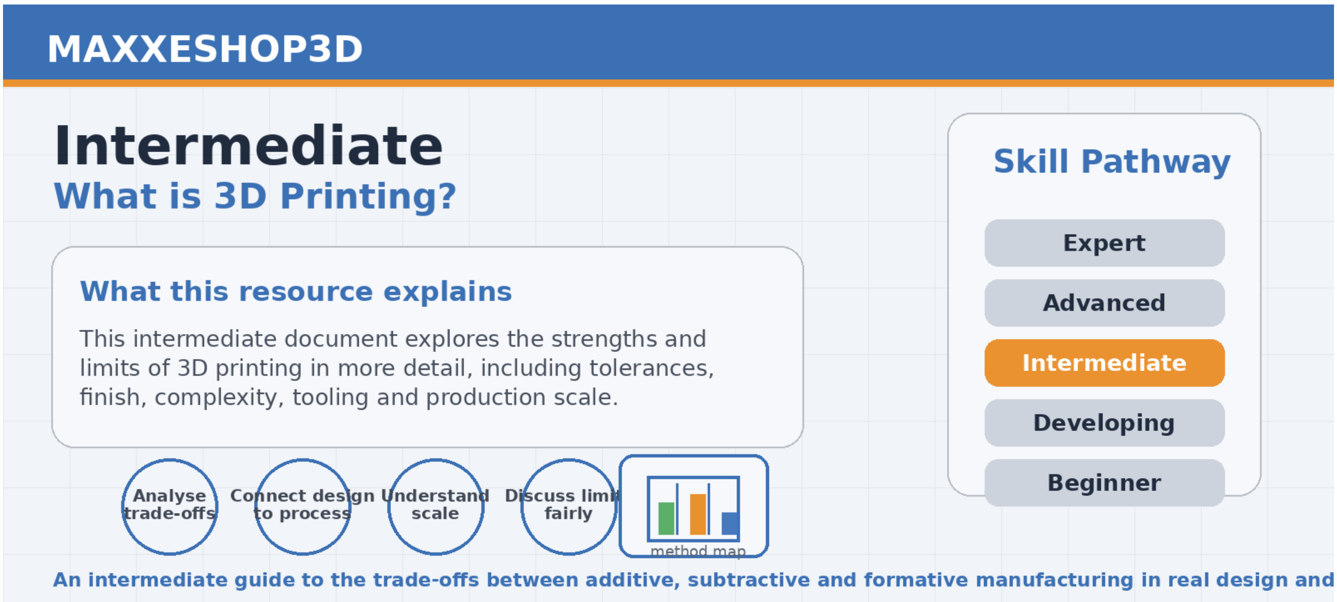


Intermediate Level • What is 3D Printing?

An intermediate guide to the trade-offs between additive, subtractive and formative manufacturing in real design and production work

This intermediate document explores the strengths and limits of 3D printing in more detail, including tolerances, finish, complexity, tooling and production scale.

Resource overview

Intermediate students should be able to explain that manufacturing methods are selected through trade-offs. 3D printing offers flexibility, customisation and design freedom, but it is not automatically the fastest, cheapest or most accurate option for every part.

This document discusses those trade-offs in more detail. It compares additive, subtractive and formative manufacturing through ideas such as lead time, tooling, waste, surface finish, dimensional control, part complexity and production volume.

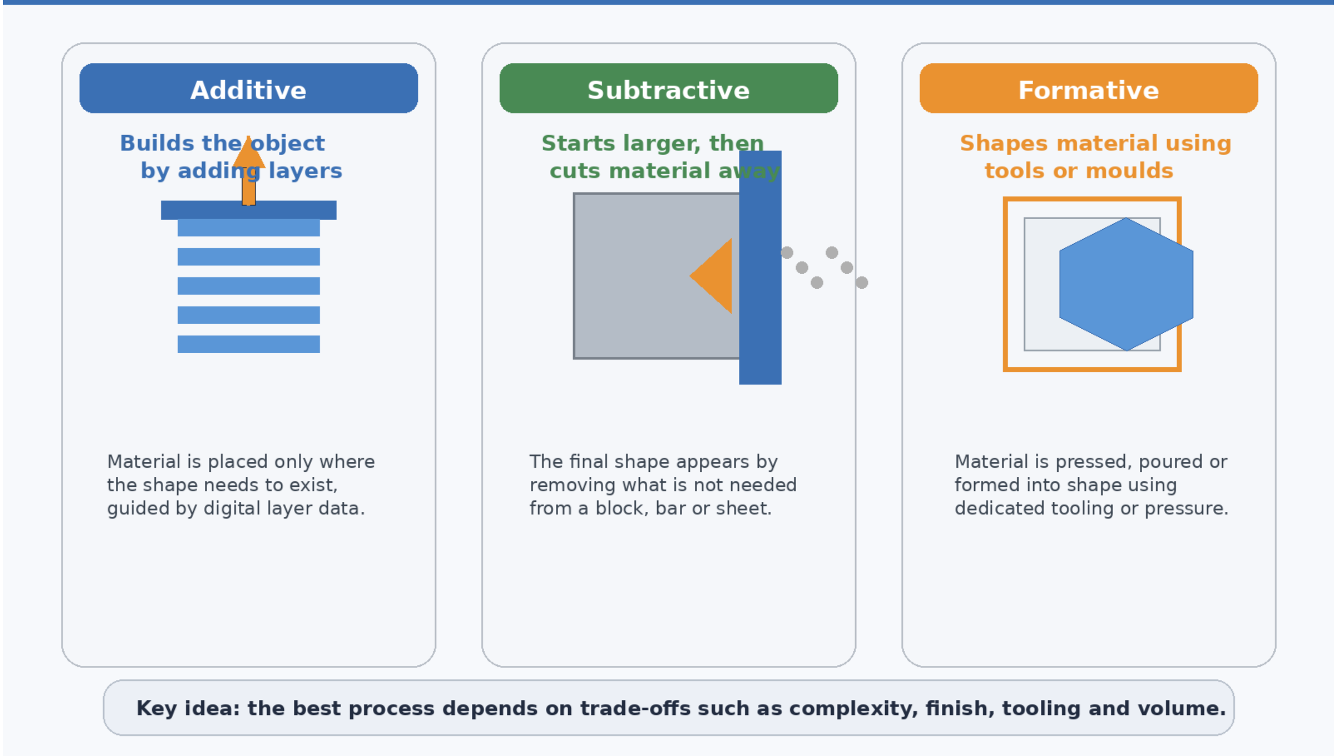
Indicative level	Intermediate
Suggested use	Manufacturing comparison lesson or design-for-manufacture discussion
Best suited to	Students ready to explain why one method may suit a design better than another
Learning focus	Analyse method selection using complexity, quantity, tooling and quality requirements
Related resource areas	Design for Manufacture • Prototyping • Evaluation

Method selection depends on trade-offs

At intermediate level, 3D printing should be studied as one option inside a broader production system. Students should understand that every method solves some problems well and introduces other limits or costs.

This makes comparison more realistic. The best manufacturing choice depends on what matters most in the job: complexity, accuracy, material behaviour, finish, speed of change, or total production quantity.

Diagram 1 • Comparing additive, subtractive and formative manufacturing



This diagram supports the intermediate explanation by showing the three main manufacturing families side by side.

Comparing manufacturing approaches

Manufacturing approach	How it works	Where it suits
Additive manufacturing	Excellent for geometry freedom, internal features and design change with limited dedicated tooling.	Commonly used for prototypes, low-volume parts, fixtures and customised products.
Subtractive manufacturing	Strong for tight tolerances, rigid materials and predictable finished surfaces.	Commonly used for precision components and machined engineering parts.
Formative manufacturing	Strong when large numbers of repeated parts are needed from prepared tooling.	Commonly used for moulded, cast, pressed or formed production items.
Lead time	Often fast to start because the main preparation is digital rather than tool-based.	Useful when rapid turnaround is more important than very high-volume efficiency.
Surface and tolerance	May require post-processing if very smooth finish or tight tolerances are needed.	Good for learning that build method affects part quality outcomes.
Economics by quantity	Often strong at low quantity but less efficient per part at very high volumes.	Shows why process choice changes when production scale changes.

Why 3D printing is powerful for prototyping

Prototyping is one of the clearest strengths of 3D printing because the method starts from digital data and does not usually require dedicated moulding tools. A designer can create a concept, print it, inspect it, adjust the model and print again. This makes the learning cycle between idea and object much shorter.

That short cycle is valuable because early prototypes are rarely perfect. Designers often need to test size, assembly, ergonomics, clearance, shape or visual appearance. A method that allows quick revision can reduce both time and uncertainty during development.

This is why 3D printing is often used even when the final product may later be made by another process. The advantage is not always that 3D printing is the final best production method. The advantage is often that it helps teams learn faster.

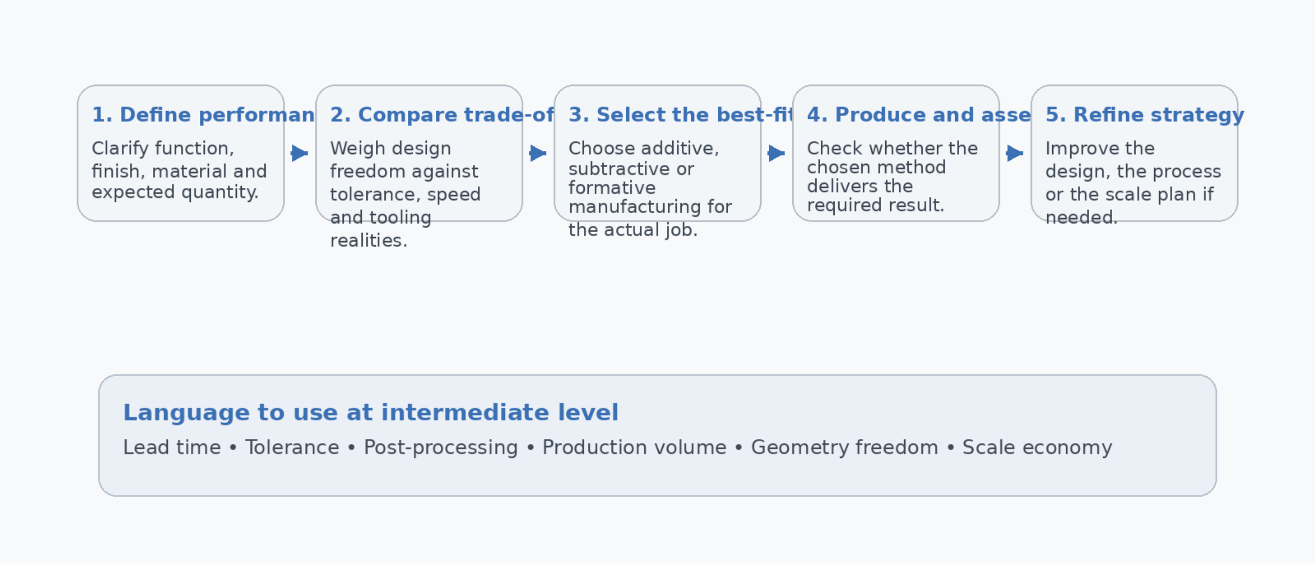
Trade-offs in finish, tolerance and material behaviour

Intermediate learners should also understand that 3D printing may show visible layer lines, process-specific surface texture or dimensional limits depending on the machine and material. In many cases, a printed part may need sanding, machining, coating or other finishing steps if a smoother or more precise result is required.

Subtractive methods can have an advantage here because the cutting process may achieve strong accuracy and high surface quality, especially when the machine and material are well controlled. Formative methods can also produce consistent repeated parts once tooling is established.

The deeper idea is that every method brings its own signature. 3D printing brings flexibility and complexity freedom, but the resulting part may behave differently from a moulded or machined part. Understanding those differences helps students compare methods honestly.

Diagram 2 • Intermediate manufacturing decision workflow



The workflow diagram above shows how method choice sits inside a broader manufacturing decision at intermediate level.

Complexity and customisation are major additive strengths

A shape that is difficult to machine or expensive to tool may still be practical to print because additive manufacturing builds geometry progressively rather than forcing the whole shape to be cut from one direction or formed inside one mould cavity. Internal channels, lattice structures, labels and customised contours often become more accessible when the process is additive.

Customisation is another major strength. A design can be adjusted for one user, one site, one classroom experiment or one repair task without needing to rebuild expensive production tools. This is especially powerful in medical, educational, engineering and one-off workshop contexts.

At intermediate level, students should see these advantages not as marketing claims but as real manufacturing benefits linked to the physical logic of the process.

Why quantity changes the best answer

Quantity is one of the most important decision points in manufacturing. A process that is excellent for one part may not be the most economical for ten thousand parts. 3D printing often avoids large setup cost, which makes it attractive for short runs, prototypes and custom work.

However, formative methods can become extremely efficient when the same part is produced again and again. Once tooling exists, the cost per unit may drop dramatically and the speed of output may rise well above a layer-by-layer process. This is why large consumer products are often moulded rather than printed.

Intermediate students should therefore understand that process selection changes with scale. A realistic answer about manufacturing always includes the question: how many parts are we trying to make?

Good comparison reminders	Suggested classroom discussion
• Choose the method to match the job, not the trend. • Consider shape, quantity, material, finish and time together. • Remember that a process can be strong in one context and weak in another. • Use comparison language carefully and explain your reasoning.	• Describe one product that suits 3D printing well and explain why. • Describe one product that would likely suit subtractive or formative manufacturing better. • Explain what changes when the design changes often. • Compare the role of quantity in process selection.

Vocabulary focus

Lead time The time needed to prepare and begin making a part.	**Tolerance** How close a part is to its intended measurement.	**Post-processing** Extra work done after the main manufacturing step.
Production volume The number of parts being made.	**Geometry freedom** The ability to create shapes that are hard to make by other methods.	**Scale economy** The way cost and efficiency change as quantity increases.

Why this level matters

This level matters because real manufacturing decisions are rarely simple. Students need to learn that a strong engineering answer explains trade-offs rather than pretending one method solves every problem.

It also strengthens design judgement. When learners connect product needs to manufacturing realities, they become better at evaluating whether a concept is practical as well as imaginative.

Teacher extension prompt

Give students one prototype case and one mass-production case and ask them to justify the best process for each. Strong intermediate answers should mention trade-offs such as tooling, tolerance, complexity and volume.