

Pilot Run Report PP6

D 2.2.1







PILOT RUN REPORT - PP6

Table of Content

Introduction

Purpose, PP6 context and programme overview

Methodology

Delivery, data collection and evaluation approach

Pilot Run Data

Overall implementation

Module 1 - Think Fast, Build Smart: Design Thinking

Module 2 - Patterns with Purpose: 2D Patterns

Module 3 - Digital Bodies: 3D Bodies

Module 4 - Smart Interactions

Module 5 - Innovative Materials

Evaluation

Assessments, feedback, facilitator observations and skills impact

Best Practices and Challenges

What worked, recurring challenges and assessment tools

Stakeholders Report

Evidence boundary, policy insights and regional/EU relevance

Conclusion and Next Steps

Programme improvements and inputs for A3.3



1. Introduction

This deliverable summarises the Pilot Runs implemented by Project Partner 6 (PP6), the Association for promoting digital fabrication (FabLab Zagreb), within the DiSTT – Digital Skills Transformation Toolkit for a Resilient Labour Market project. DiSTT strengthens local digital-fabrication skills through practical re- and upskilling programmes and prepares transferable guidance for FabLabs and training organisations across Europe.

FabLab Zagreb is a Croatian non-profit association established in 2013 to promote digital fabrication through education, research, entrepreneurship and community involvement. Its PP6 pilot focused on secondary-school learners and placed particular emphasis on face-to-face delivery in school and community settings outside Zagreb, including geographically more remote communities. This approach reflects FabLab Zagreb’s commitment to accessibility, inclusion, personal empowerment and creative confidence, alongside technical competence.

The PP6 programme, “Idea to prototype, with cutting-edge fabrication technology”, comprised five independent educational modules. Learners could attend each module as a self-contained unit; no module was treated as a mandatory prerequisite for another. At the same time, the modules collectively traced a broad pathway from recognising a problem and structuring an idea to 2D and 3D fabrication, smart electronic interactions and informed material selection.

1.1. Programme overview

No.	Workshop focus	Primary practical emphasis	Target group
1	Think Fast, Build Smart – Design Thinking	Problem framing, idea development, requirements and early models	Secondary-school students
2	Patterns with Purpose – 2D Patterns	2D/3D relationships, laser cutting, engraving and pattern design	Secondary-school students
3	Digital Bodies – 3D Bodies	CAD modelling, STL preparation, slicing and 3D printing	Secondary-school students
4	Smart Interactions	Basic electronics, sensors, actuators, Arduino and simple code	Secondary-school students
5	Innovative Materials	Recycled, recyclable and smart materials; heat and UV response	Secondary-school students

Across the five modules, the reports record 13 module-group implementations, 27 live meetings and 109 modular participations. Because the modules were independent and some learners may have attended more than one module, these figures represent module-level participation rather than 109 unique individuals.



2. Methodology – Data Collection and Evaluation Approach

The PP6 workshops combined concise introductory explanations with demonstrations, practical tasks, teamwork, worksheets or seminar assignments, and mentoring by the FabLab delivery team. The delivery model consistently moved from an accessible example to guided practice and then to a learner or team output. Depending on the module, outputs included structured concepts, sketches, cardboard models, laser-cut or engraved elements, CAD files, STL files, simple 3D-printed or 3D-pen forms, electronic circuits, seminar documentation and objects made from recycled plastic.

Evaluation used pre- and post-workshop self-assessment questionnaires, open responses and facilitator observations. Quantitative items used a five-point scale, where 1 represented very low understanding or confidence and 5 represented high understanding or independent application. Indicator names in the supplied charts are abbreviated for readability; the English tables and descriptions in this report explain their meaning.

Module-level results were analysed across all delivery locations for the same module. Individual pre- and post-responses were not linked by anonymous identifiers, so results show aggregate change rather than individually matched learning gains. Module 4 also has unequal response counts (31 PRE and 32 POST); this limitation is retained transparently. The results should therefore be interpreted as evidence of perceived development and implementation quality, supported by qualitative observations and practical activity, rather than as controlled causal impact measurements.

The Croatian source reports were treated as the source of truth. All delivery dates, attendance figures, response counts, mean values, qualitative findings, good practices, challenges and recommendations have been translated into English. References in the source documents to the contracted implementer have been replaced throughout by the neutral term “FabLab delivery team”, as requested.



3. Pilot Run Data

3.1. Overall implementation

Module	Groups / locations	Live meetings	Modular participations	PRE / POST	Mean PRE	Mean POST	Change
1	3	6	24	24 / 24	1.43	4.51	+3.08
2	2	4	14	14 / 14	1.91	4.11	+2.20
3	3	5	23	23 / 23	2.03	4.61	+2.58
4	3	8	31	31 / 32	2.18	4.59	+2.41
5	2	4	17	17 / 17	2.38	4.69	+2.31
TOTAL	13	27	109	109 / 110	—	—	—

The table aggregates module-level records. PRE/POST means are not combined into a single programme score because module indicators differed and the modules were delivered as independent learning units.



3.1. Module 1 – Think Fast, Build Smart

Design Thinking – from problem and idea to a structured concept

Purpose, target group and delivery approach

Module 1 was an introductory, self-contained unit focused on developing students' project ideas. It introduced the basic transition from an observed problem to an idea, goal, solution description and first set of possible solution variants. The target group consisted of secondary-school students at school sites and a FabLab delivery venue. Most participants had no previous experience of systematic idea development, Design Thinking, agile ways of working, morphological matrices or requirements lists.

The module provided an initial framework for articulating ideas more clearly. Although it was not a prerequisite for another module, it could help participants organise a project task, explain a solution and work more effectively if they later chose another independent programme module.

Workshops combined a short introduction, discussion, practical examples, teamwork, a worksheet and mentored refinement. Learning was grounded in simple, relatable examples rather than long frontal lectures.

- Distinguishing a problem, idea, goal, description and solution.
- Introducing Design Thinking and an agile/iterative approach through practical examples.
- Completing a team seminar assignment and gradually developing a shared worksheet.
- Refining ideas through sketches, solution descriptions, a morphological matrix, a requirements list and simple cardboard models.
- Collecting PRE and POST self-assessments, open responses and facilitator observations.

Delivery record

Delivery group	Location	Meeting dates	Meetings	Learners
Gimnazija Matija Mesić Slavonski Brod – group B	Gimnazija Matija Mesić, Slavonski Brod	6 Mar 2026; 13 Mar 2026	2	10
Gimnazija Nova Gradiška	Gimnazija Nova Gradiška	5 Mar 2026; 12 Mar 2026	2	10
FabLab delivery team	FabLab delivery venue, Naselje Slavonija I 3/2, Slavonski Brod	7 May 2026; 15 May 2026	2	4
TOTAL			6	24

The 24 participants are module-level records across the three locations. The analysis combines all Module 1 implementations.

Workshop content and learner activities

- Recognising and describing a real-life or school-based problem.
- Distinguishing an idea, goal, solution description and final solution.
- Understanding users and problems through an introductory Design Thinking lens.
- Using iteration, feedback and refinement as an introduction to agile development.
- Generating solution variants with a morphological matrix and defining an initial requirements list.
- Developing a team seminar task and worksheet through sketches, discussion, feedback and simple cardboard models.

A key learning step was moving from an abstract idea to something that could be described, visualised and developed further. Cardboard forms and sketches helped students connect the problem, function, user and possible solution.

Evaluation and competence development

Module 1 collected 24 PRE and 24 POST responses. The overall mean rose from 1.43 to 4.51, an increase of 3.08 points. Results indicate substantial growth in understanding the idea-development process and confidence in using basic tools.

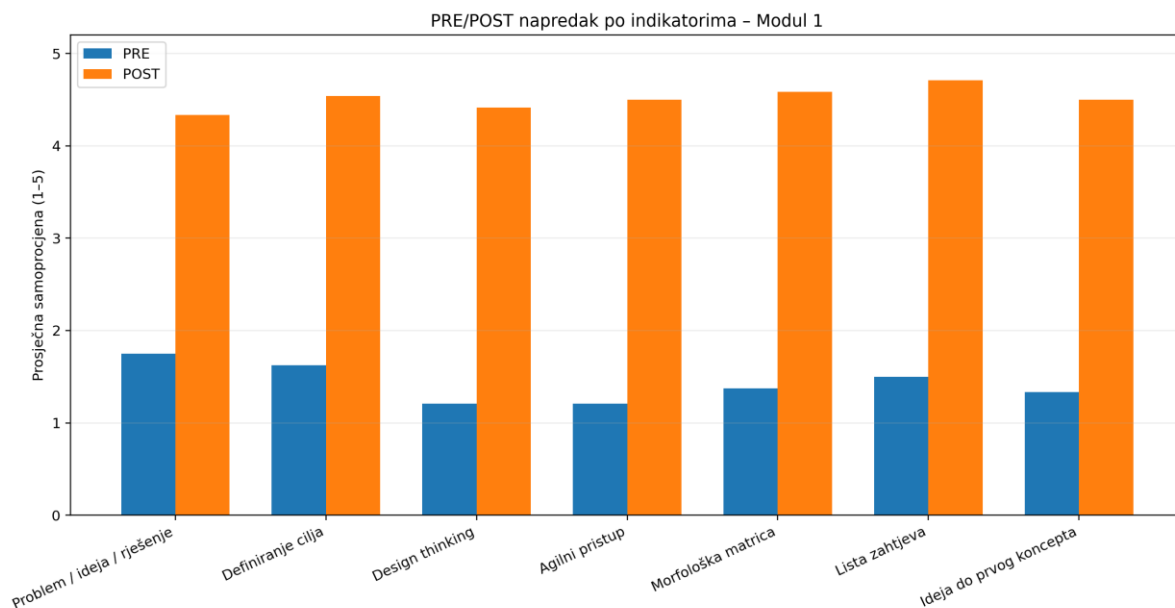


Figure 1. Module 1 PRE/POST mean scores by abbreviated indicator (source chart).

Indicator	PRE	POST	Change
Response count	24	24	—
Overall self-assessment mean	1.43	4.51	+3.08
Personal progress	—	24 students reported progress	100% positive

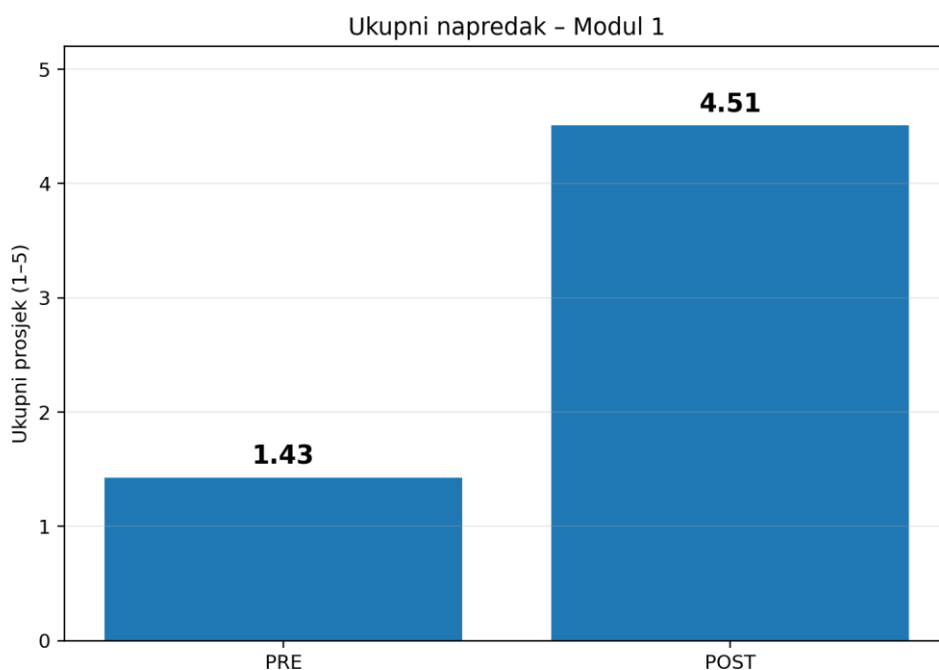


Figure 2. Overall Module 1 PRE/POST mean (source chart).

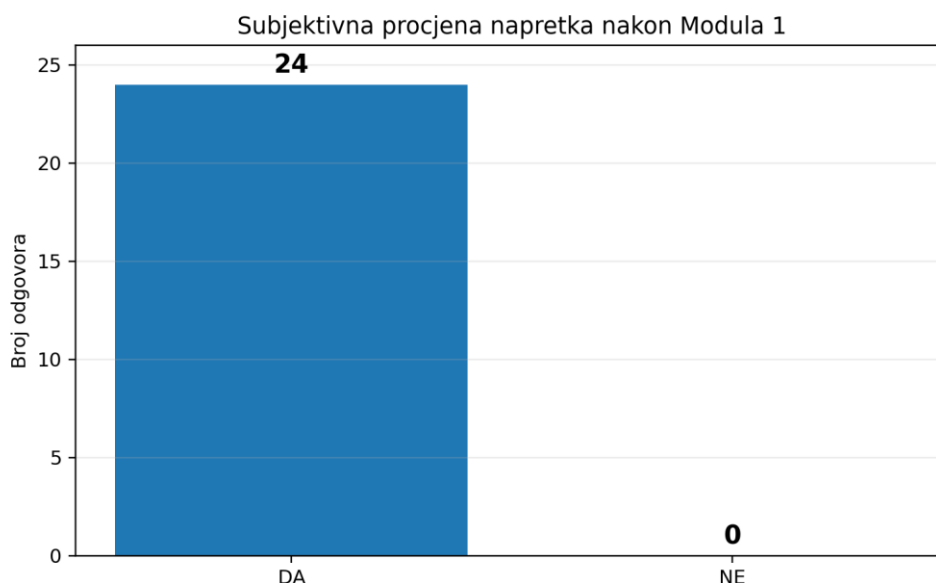


Figure 3. Participants' self-reported progress after Module 1 (source chart).

Participant feedback and facilitator observations

Open responses and workshop observations show that concrete examples, teamwork, the worksheet and step-by-step guidance were most useful. Before the workshops, some learners did not know how to begin a project task, describe a problem clearly or distinguish an idea from a solution. Afterwards, they described the problem, goal and basic solution more confidently and could explain why several alternatives should be considered.

The morphological matrix was particularly effective when explained through simple examples: students understood that a solution can be decomposed into functions and that combining alternatives generates more possible solutions. Cardboard and sketching supported students who learn more readily from physical representations. The strongest competence development appeared in understanding the idea-development process, structuring an initial project task, communicating in teams and converting a vague notion into a described concept. Presenting, explaining and revising ideas also developed basic presentation skills.

Good practices, challenges and improvements

- Use everyday examples instead of a long theoretical introduction.
- Retain the worksheet as a clear structure for team idea development.
- Combine discussion, sketching, writing and cardboard modelling for different learning styles.
- Use mentoring questions to guide learners without prescribing a finished solution.
- Keep short iterations and feedback so learners experience ideas as improvable rather than fixed.
- Address the initial confusion between problem, idea, goal and solution with an extra mini-task.
- Provide a gallery of student ideas and visual templates for learners who struggle with a blank page.
- Create a shared digital space for worksheets, facilitator comments and tracked refinements.
- Continue PRE/POST assessment and add one short structured question on what helped most.

Module 1 was successful as an introductory space for project competence. The quantitative improvement and qualitative evidence support retaining a practical, example-led and mentored model, with stronger visual scaffolds and iterative refinement.



3.2. Module 2 – Patterns with Purpose

2D patterns – from flat geometry and digital preparation to fabricated elements

Purpose, target group and delivery approach

Module 2 was a self-contained unit on 2D technologies, patterns and the transition from a flat shape to a functional object or spatial form. Secondary-school students at two pilot locations learned the difference between 2D and 3D forms, the function of patterns, the possibilities of laser cutting and engraving, and the relationship between a sketch, digital preparation and physical fabrication.

Delivery combined a short introduction, demonstration, hands-on tasks and teamwork. Students observed how flat, pre-cut parts form a 3D model and explored repeated geometry, laser-cut or engraved elements, simple tags and the moiré effect. They developed their own sketches and dimensions while discussing feasibility, size, material and technical constraints with facilitators.

Delivery record

Delivery group	Location	Meeting dates	Learners
Gimnazija Matija Mesić Slavonski Brod – group B	Gimnazija Matija Mesić, Slavonski Brod	20 Mar 2026; 27 Mar 2026	8
Gimnazija Nova Gradiška	Gimnazija Nova Gradiška	9 Apr 2026; 16 Apr 2026	6
TOTAL		4	14

Workshop content and learner activities

- Difference between 2D and 3D: width and height in a flat representation and the addition of depth in a spatial object.
- Patterns, repetition, rhythm, geometry and the visual function of a pattern.
- Laser cutting and engraving, including the distinction between cutting lines and engraved areas or marks.
- Assembly of a 3D form from pre-cut flat elements.
- Fabrication of simple elements, tags or markers with laser cutting and engraving.
- Exploration of the moiré effect by overlaying similar patterns.
- Own sketches, dimensions and ideas for 2D elements, supported by team mentoring on feasibility and material constraints.

Practical tasks connected sketches and dimensions to machine fabrication. Some learners developed physical cardboard or other-material elements to test form and function quickly before more complex fabrication.

Evaluation and competence development

Fourteen students completed both PRE and POST questionnaires. The overall mean increased from 1.91 to 4.11 (+2.20). The largest gains were in preparing a design for the laser, understanding how a 2D form can become a 3D object, and understanding 2D patterns.

Code	Question / competence	PRE	POST	Change
P1	Difference between 2D and 3D forms	2.93	4.00	+1.07
P2	Understanding 2D patterns	1.79	4.21	+2.43
P3	What a laser cutter does: cutting and engraving	1.57	3.86	+2.29
P4	Drawing a simple product sketch	2.00	4.07	+2.07
P5	Designing a simple 2D shape for fabrication	2.00	4.29	+2.29
P6	Preparing a design for the laser	1.14	3.93	+2.79
P7	Obtaining a 3D object from 2D shapes	1.93	4.43	+2.50

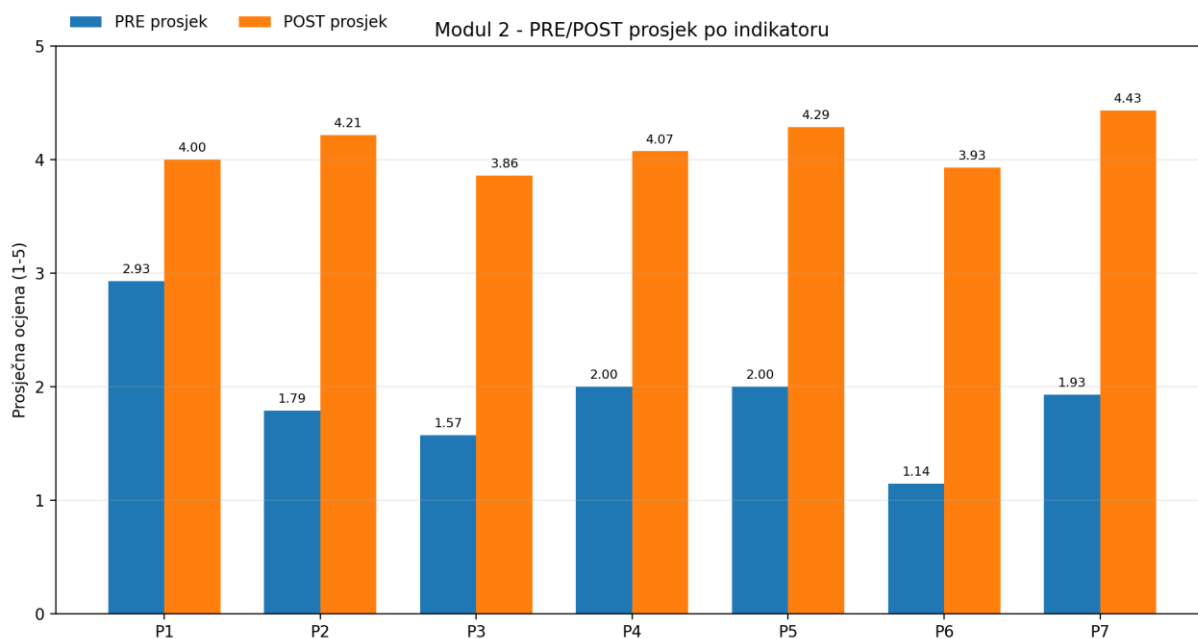


Figure 4. Module 2 PRE/POST mean scores by indicator (source chart).

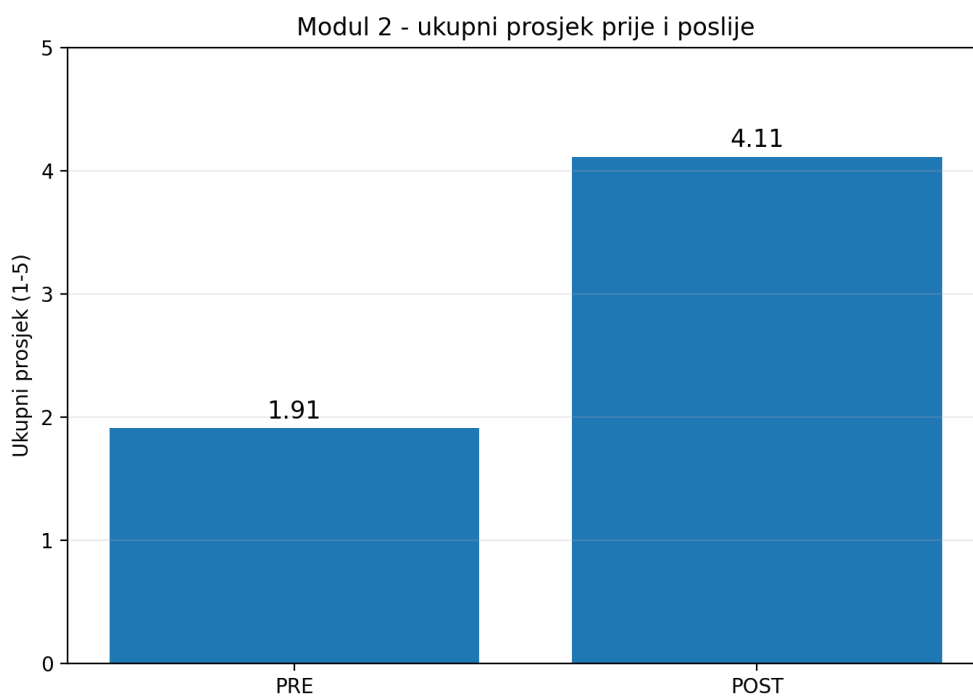


Figure 5. Overall Module 2 PRE/POST mean (source chart).

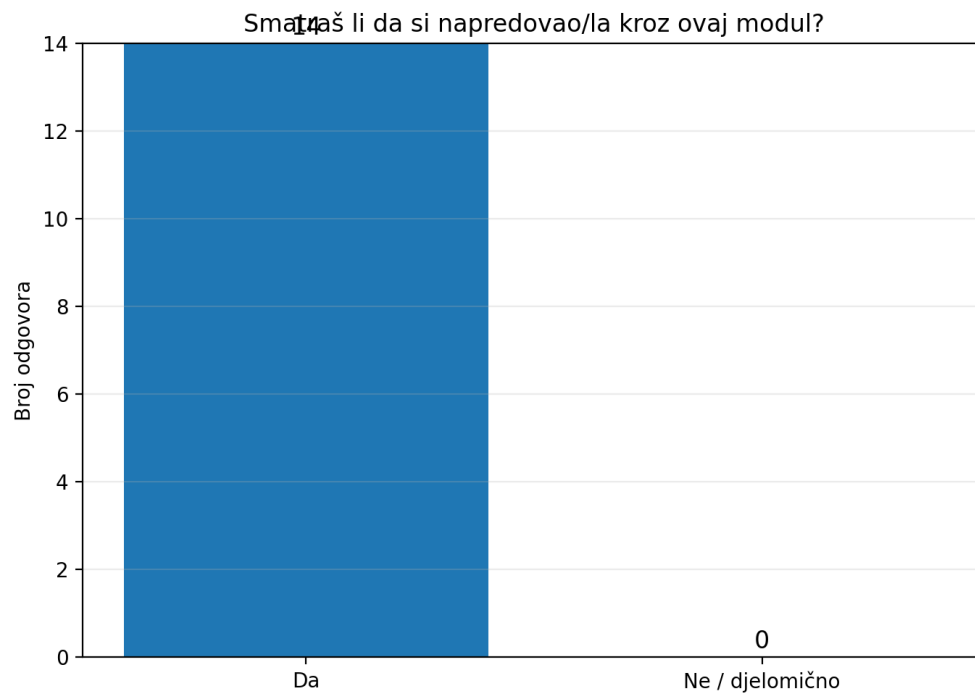


Figure 6. Participants' self-reported progress after Module 2 (source chart).

Participant feedback and facilitator observations

Before the module, students most often identified dimensioning, drawing, tool use, spatial orientation and unfamiliar technology as difficult. After the module, their concerns were more specific: wall thickness, technical drawing, laser operation, and selecting correct laser power and cutting speed. The shift from general uncertainty to technically precise challenges indicates more realistic understanding of fabrication. All 14 students reported that they had progressed.

Students responded best to hands-on work, short demonstrations and visible outcomes: a cut or engraved element, a 3D form assembled from 2D parts, or the visible effect of a pattern. The central learning challenge was converting an idea or sketch into a technically feasible form and understanding why dimensions, material thickness, line spacing, power and speed affect the result.

Good practices, challenges and improvements

- Combine a short theoretical introduction with an immediate practical demonstration.
- Use assembly of a 3D form from 2D parts to make the flat-to-spatial relationship visible.
- Retain small teams, mentoring and concrete material/laser tasks.
- Discuss mistakes, dimensions and machine limitations openly.
- Start from basic concepts for learners without previous 2D-technology experience.
- Allocate more time to technical drawing, dimensioning, file preparation and test cuts at different laser settings.
- Provide examples of good and poor sketches plus technically correct sample files.
- Use a sketch template with fields for dimensions, material, thickness, cutting and engraving.
- Create a shared folder of student work and facilitator comments.

Module 2 successfully built foundational understanding of 2D shapes, patterns, laser cutting and engraving. It also helped learners recognise the practical relationship between an idea, material, machine parameters and a fabricated object.



3.3. Module 3 – Digital Bodies

3D bodies – CAD modelling, model preparation and additive fabrication

Purpose, target group and delivery approach

Module 3 was a self-contained introduction to 3D technologies, digital modelling and the conversion of an idea into a physical or digital 3D prototype. Secondary-school students had varied prior exposure to 3D printing, but most lacked independent CAD modelling and print-preparation skills.

Workshops combined a concise introduction, technology demonstrations, work in Onshape, mentored practical modelling, preparation of files for 3D printing and observation of how a digital model becomes a physical object. Learners compared 2D and 3D representation, learned coordinate-space logic, explored 3D printing and a 3D pen, and developed simple functional parts in teams.

Delivery record

Delivery group	Location	Meeting dates	Meetings	Learners
Gimnazija Matija Mesić Slavonski Brod – group B	Gimnazija Matija Mesić, Slavonski Brod	10 Apr 2026; 24 Apr 2026	2	10
Gimnazija Nova Gradiška	Gimnazija Nova Gradiška	19 Mar 2026; 26 Mar 2026	2	10
FabLab delivery team	FabLab delivery venue, Naselje Slavonija I 3/2, Slavonski Brod	29 May 2026	1	3
TOTAL			5	23

Workshop content and learner activities

- Distinguishing 2D representation from a 3D model and understanding spatial axes and volume.
- Basics of additive manufacturing and the 3D-printing process.
- Onshape CAD workflow: sketching, dimensions, extrude, holes, slots and fillets.
- Creation of a simple 3D model such as a tag or basic technical element.
- STL export, slicing, layers, the first printed line and fabrication constraints.
- Use of a 3D pen for physical understanding of space and rapid form testing.
- Team development of functional parts such as supports, connectors, housings and holders.

The essential step was the transition from an on-screen representation to a manufacturable object. Students learned that a 3D model is a technical description with dimensions, form, function and fabrication constraints. Teams prepared or submitted models as seminar/project tasks; some groups proceeded to printing or print preparation, while others focused on core CAD procedures.

Evaluation and competence development

Twenty-three PRE and 23 POST responses were collected. The overall mean increased from 2.03 to 4.61 (+2.58), indicating substantial growth in understanding 3D modelling, 3D printing and confidence with basic digital tools.

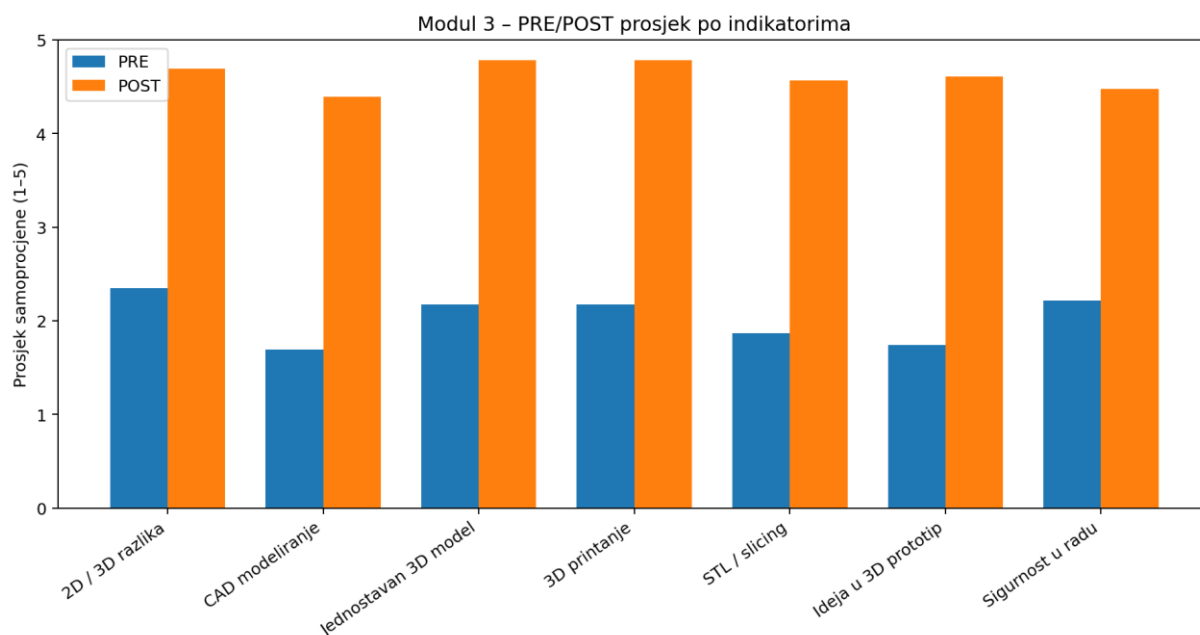


Figure 7. Module 3 PRE/POST mean scores by abbreviated indicator (source chart).

Indicator	PRE	POST	Change
Response count	23	23	—
Overall self-assessment mean	2.03	4.61	+2.58
Personal progress	—	21 yes; 2 partly; 0 no	Most responses positive

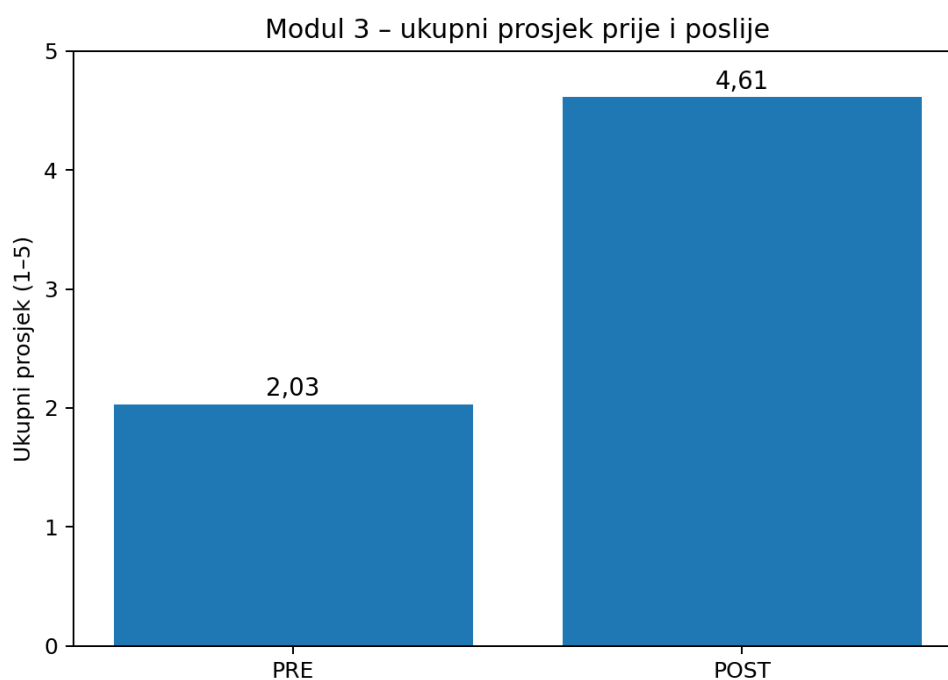


Figure 8. Overall Module 3 PRE/POST mean (source chart).

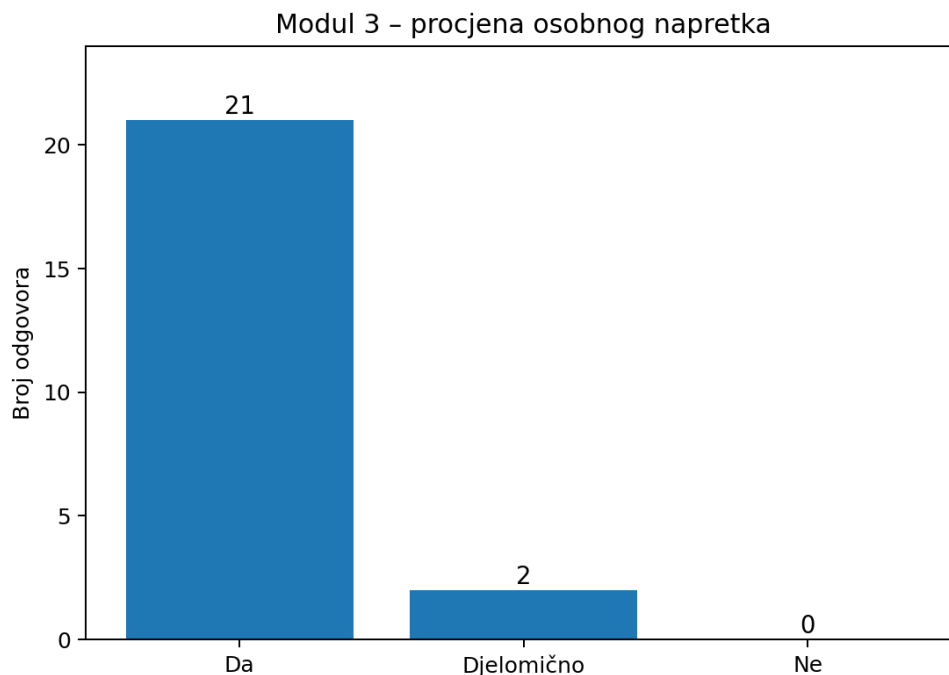


Figure 9. Participants' self-reported progress after Module 3 (source chart).

Participant feedback and facilitator observations

Before the module, students most often cited software use, modelling, navigating a CAD environment, print preparation and general unfamiliarity with 3D technologies. Some were encountering this type of work for the first time. After the module, responses shifted towards precise challenges: modelling in Onshape, accurate spatial design, print preparation and converting an intended idea into a 3D model. Being able to name the technical challenge more clearly is itself a positive learning indicator.

Facilitator observations identified the clearest progress in distinguishing an idea from a 3D model, navigating basic CAD functions, understanding STL and recognising that a model must be printable. A guided tag example and immediate printing demonstration connected digital design to a physical result.

Good practices, challenges and improvements

- Start with a very simple model, such as a tag, for learners without CAD experience.
- Combine demonstration, independent practice and mentoring to accelerate entry into Onshape.
- Show STL export and print preparation to explain the entire model-to-object workflow.
- Use a 3D pen for learners who understand space through physical making.
- Prefer simple functional parts to overly broad or abstract assignments.
- Allow time for learners to understand interfaces, planes, sketches, dimensions and spatial reasoning.
- Repeat STL, slicing and printability concepts and provide individual CAD support.
- Prepare short videos for sketching, dimensioning, extrude, holes, fillets and STL export.
- Offer a gallery of adaptable examples and a printability check for thin walls, small holes and unclear connections.
- Continue PRE/POST assessment and ask which CAD step was most difficult.

Module 3 successfully developed basic digital-spatial literacy. The practical workflow demonstrated that 3D models require structure, dimensions, function and fabrication preparation; future delivery should retain the guided approach while increasing examples, templates and individual CAD support.



3.4. Module 4 – Smart Interactions

Basic electronics, sensors, actuators, microcontrollers and simple interactive systems

Purpose, target group and delivery approach

Module 4 introduced smart interactions, basic electronics, sensors, actuators and microcontrollers. Secondary-school students at two schools and a FabLab delivery venue explored how an electronic circuit, program logic and user function combine in a simple smart system.

Workshops moved from basic concepts – microcontrollers, Arduino, sensors, actuators, AC/DC voltage, LED diodes, resistors, conductors and breadboards – to practical circuit assembly and simple code. Learners tested visible behaviours such as an LED, traffic-light sequence or smart-light concept, and teams prepared a seminar task documenting the topic, real-world use, equipment, circuit, program and conclusion.

Delivery record

Delivery group	Location	Meeting dates	Meetings	Learners
Gimnazija Matija Mesić Slavonski Brod – group A	Gimnazija Matija Mesić, Slavonski Brod	2 Mar; 9 Mar; 23 Mar; 20 Apr; 4 May 2026	5	19
Gimnazija Nova Gradiška	Gimnazija Nova Gradiška	23 Apr 2026; 30 Apr 2026	2	8
FabLab delivery team	FabLab delivery venue, Naselje Slavonija I 3/2, Slavonski Brod	21 May 2026	1	4
TOTAL			8	31

Workshop content and learner activities

- Role of a microcontroller and basic Arduino concepts.
- Difference between sensors and actuators and between AC and DC voltage.
- Use of LEDs, resistors, conductors and a breadboard.
- Assembly, analysis, measurement and functional checking of simple electronic circuits.
- Connection between a physical circuit and program behaviour through visible outcomes.
- Team selection of a topic and components, description of function, and preparation of a seminar report with circuit and code explanation.

The seminar task extended learning beyond demonstration by requiring students to explain and document a technical solution. The knowledge can support later digital-fabrication or prototyping work, but Module 4 was evaluated as an independent unit.

Evaluation and competence development

The overall mean increased from 2.18 in the 31 PRE responses to 4.59 in the 32 POST responses (+2.41). Because responses were not individually linked and the group sizes differ, this is an aggregate comparison. The largest gains were in understanding a microcontroller, writing or understanding a simple program, and designing a simple smart system.

Indicator	PRE mean	POST mean	Change
Microcontroller	1.90	4.81	+2.90
Sensors and actuators	1.87	4.26	+2.39
Electronic components	2.87	4.65	+1.77
Simple program	1.97	4.58	+2.61
Smart system	2.00	4.52	+2.52
AC/DC voltage	2.23	4.65	+2.42
Electronic circuit	2.42	4.68	+2.26

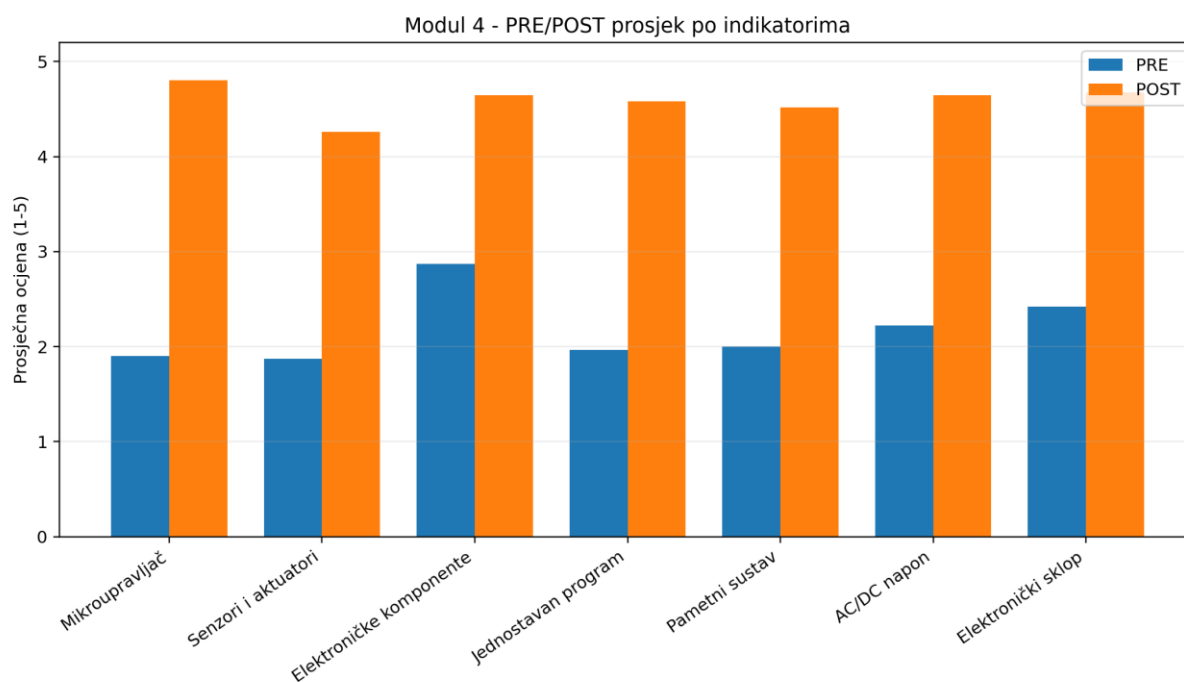


Figure 10. Module 4 PRE/POST mean scores by indicator (source chart).

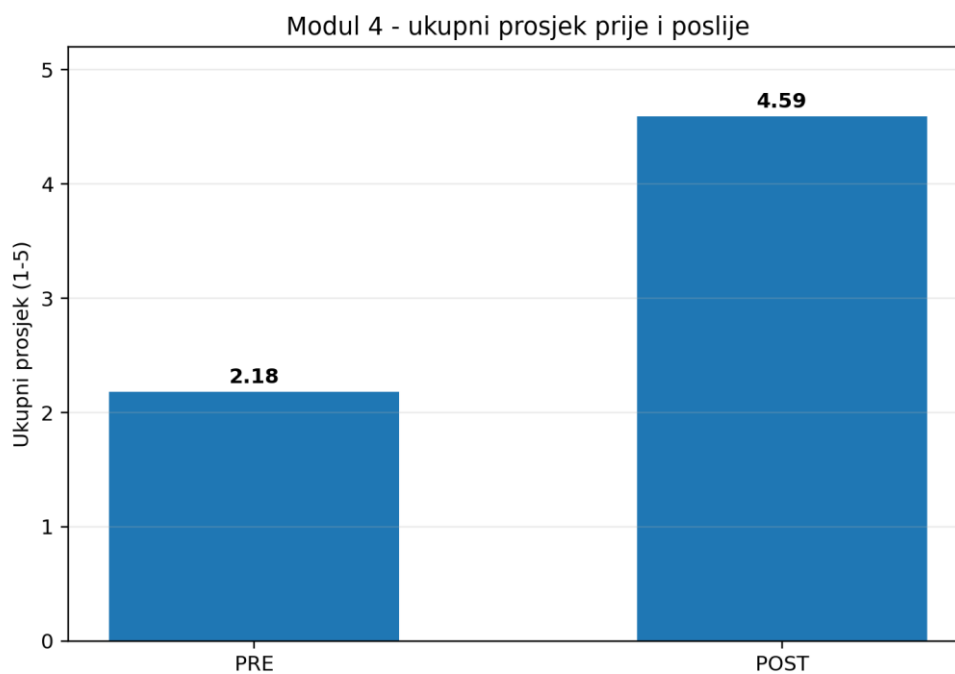


Figure 11. Overall Module 4 PRE/POST mean (source chart).

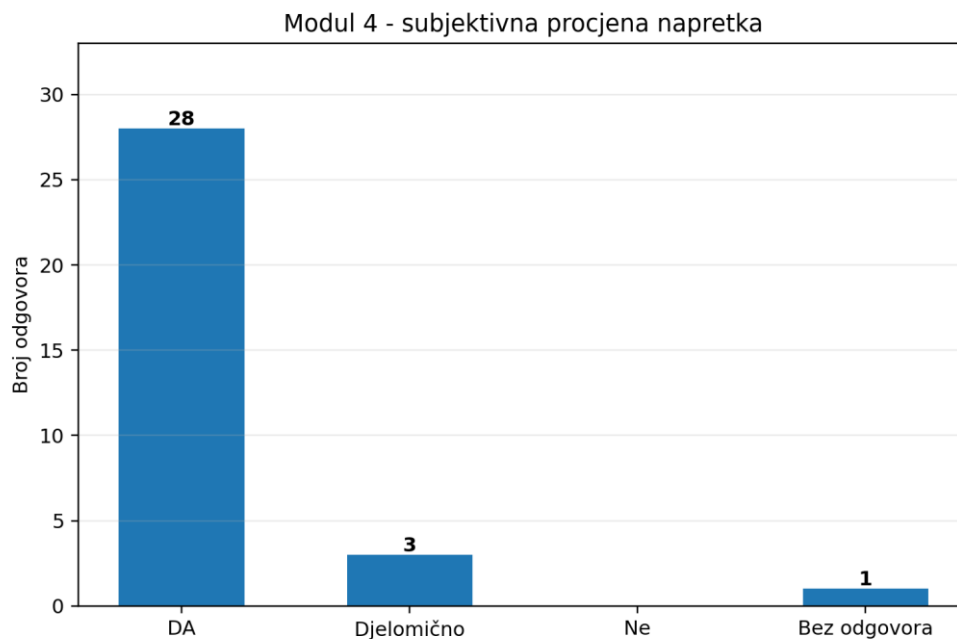


Figure 12. Participants' self-reported progress after Module 4 (source chart).

Before delivery, 22 students reported no prior experience with Arduino or electronics and nine reported previous experience. Initial uncertainties centred on programming, code, circuit connections, voltage and general electronics. In the POST questionnaire, 28 responses indicated progress, three indicated partial progress and one was blank.

Participant feedback and facilitator observations

Learners responded best when a concept was immediately associated with a physical component and visible reaction, such as illuminating an LED or changing a state in a simple circuit. Small teams, concrete tasks and immediate testing were effective. The main difficulty was program code: some participants had no programming experience or struggled to connect syntax with physical behaviour.

Good practices, challenges and improvements

- Pair short explanations with practical tasks and visible results such as LEDs or traffic lights.
- Use gradual concept introduction, teamwork and a seminar assignment that documents the solution.
- Provide mentoring during circuit assembly, testing and debugging.
- Respond to varied prior knowledge and initial programming uncertainty with tasks at different levels.
- Allow more time for independent circuit assembly and error correction.
- Plan for limited component availability so all teams can work effectively.
- Prepare quick-reference cards for common circuits and code examples.
- Provide a template for documenting the circuit, program and real-world application.

Module 4 successfully moved learners from passive familiarity with electronics towards practical understanding of a simple smart system. It also developed documentation, explanation and presentation skills through the team seminar task.



3.5. Module 5 – Innovative Materials

New and recycled materials – properties, responses and sustainable applications

Purpose, target group and delivery approach

Module 5 was a self-contained unit on innovative, recycled, recyclable and smart materials. It encouraged secondary-school learners to see a material not only as a passive product component but as something that may perform a function, respond to its environment or enable more sustainable fabrication.

Delivery combined a short introduction, demonstration experiments, practical work and mentored discussion. Learners observed responses to heat and UV light and saw how waste plastic can become a new functional form. Concepts included recycling, recyclability, reuse, thermal formability, flexibility, strength and functional material change.

Delivery record

Delivery group	Location	Meeting dates	Learners	Target group
Gimnazija Matija Mesić Slavonski Brod – group B	Gimnazija Matija Mesić, Slavonski Brod	8 May 2026; 15 May 2026	10	Secondary-school students
Gimnazija Nova Gradiška	Gimnazija Nova Gradiška	7 May 2026; 28 May 2026	7	Secondary-school students

The total is 17 modular participations across two groups and four dated meetings.

Workshop content and learner activities

- Analysis of recycled, recyclable and smart materials.
- Demonstration of UV-responsive material that changes visibility or colour under UV light.
- Heat-shrink tubing as an accessible example of a material changing shape with heat.
- Preparation and processing of plastic caps as recycled input material.
- Thermal forming of plastic and observation during heating and cooling.
- Fabrication of a useful object, such as a small container or flowerpot, from recycled plastic.
- Discussion of possible applications in everyday products and student project ideas.

The activities made material properties, sustainability and functional response tangible. Although knowledge of materials can support later prototyping, Module 5 was treated as an independent educational unit.

Evaluation and competence development

Seventeen students completed the PRE and POST questionnaires. The overall mean increased from 2.38 to 4.69 (+2.31). The largest relative gain was for smart materials (+2.82), the indicator with the lowest starting value.

Indicator	PRE mean	POST mean	Change
Recyclable materials	2.35	4.88	+2.53
Recyclable versus recycled	2.12	4.47	+2.35
Reuse of waste	2.53	4.65	+2.12
Material properties	3.00	4.76	+1.76
Heat forming of plastic	2.47	4.71	+2.24
Smart materials	1.88	4.71	+2.82
Application in a product	2.29	4.65	+2.35

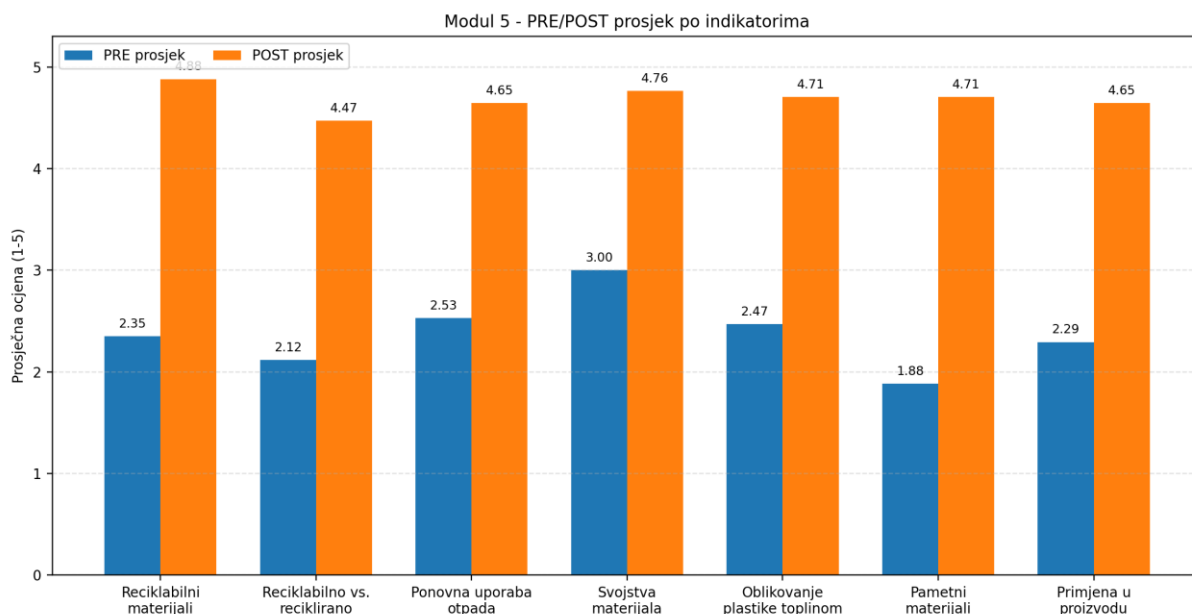


Figure 13. Module 5 PRE/POST mean scores by indicator (source chart).

At the start, 13 of 17 learners reported that they had not previously encountered recycled, recyclable or smart materials, while four reported prior experience. After delivery, 15 stated that the module was their first practical experience of such materials.

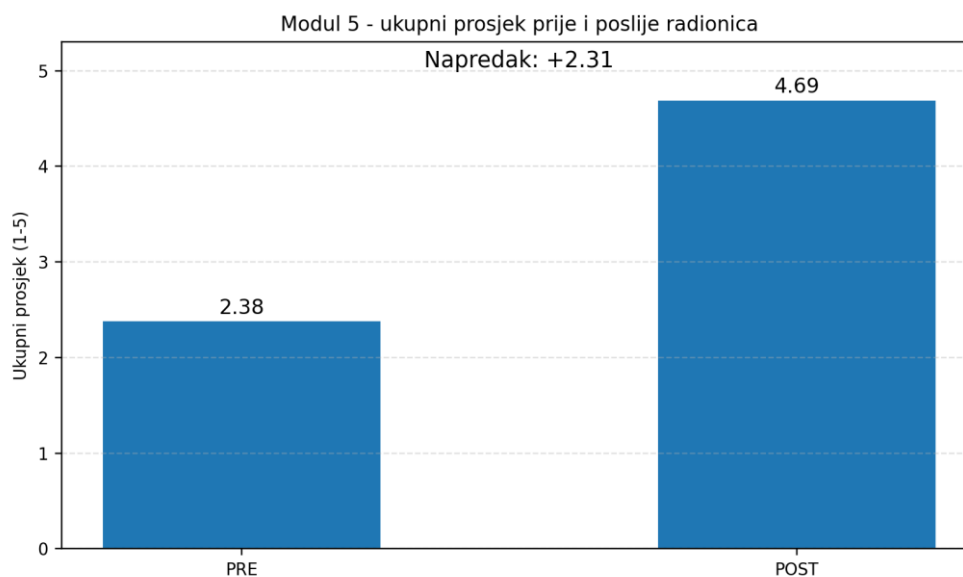


Figure 14. Overall Module 5 PRE/POST mean (source chart).

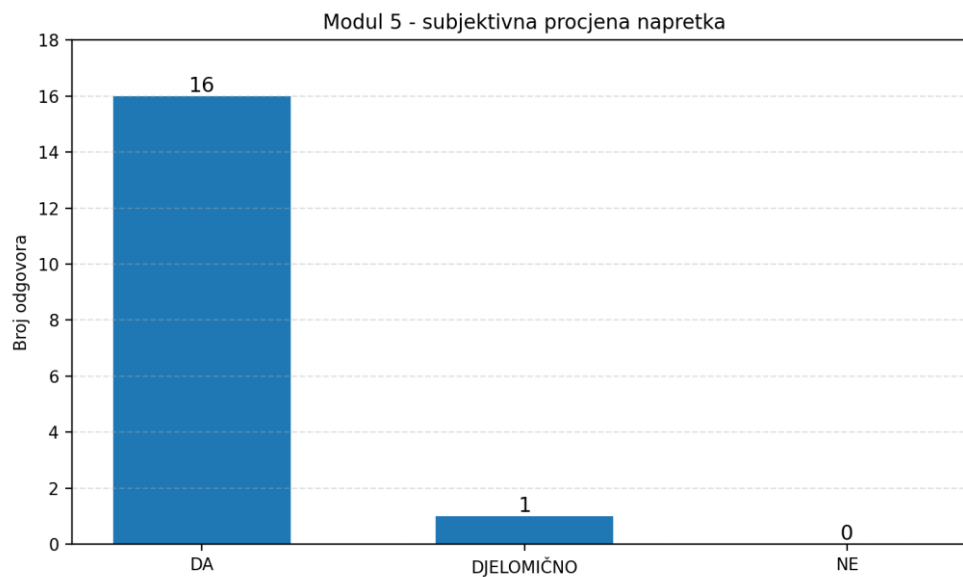


Figure 15. Participants' self-reported progress after Module 5 (source chart).

Sixteen learners answered yes to the personal-progress question and one answered partly; no learner answered no.

Participant feedback and facilitator observations

Before delivery, smart materials, heat-forming plastic and practical uses of recycled material were least clear. Learners benefited from immediate demonstrations: visible UV reactions, shrinking heat-shrink tubing, and heating and forming plastic. Connecting sustainability concepts to a useful object made from recycled material was particularly effective. Facilitators observed that theory should remain short and be followed quickly by a practical example; abstract concepts work best when shown through a simple experiment.

Good practices, challenges and improvements

- Use short demonstrations before detailed explanation.
- Prioritise visible material change: UV reaction, heat shrinkage and plastic forming.
- Connect sustainability to a concrete useful object made from recycled caps.
- Combine individual observation, team discussion and mentoring.
- Explain abstract terms repeatedly through practical examples.
- Allow sufficient preparation, cooling and safe handling time; maintain supervision and explicit safety instructions around heat and tools.
- Introduce rotating experiment stations for several smart materials.
- Pre-prepare samples to leave more time for analysis and discussion.
- Use a worksheet linking stimulus, material reaction and product application.
- For advanced groups, compare plastic types and suitability for reprocessing.

Module 5 successfully made innovative, recycled, recyclable and smart materials understandable through direct experience. The demonstration-led practical model is appropriate for secondary-school learners and should be retained with added worksheets and more small examples.



4. Evaluation

4.1. Pre- and post-workshop assessment

All five modules recorded clear increases in aggregate self-assessment means. Module 1 had the largest mean change (+3.08), while the other modules increased by +2.20 to +2.58. The 109 PRE and 110 POST records are questionnaire responses across independent modules, not unique-person counts. The evaluation design is strongest as a consistent indicator of perceived development and should be interpreted alongside practical outputs and observations.

Module	PRE / POST responses	PRE mean	POST mean	Change	Personal-progress response
1	24 / 24	1.43	4.51	+3.08	24 yes
2	14 / 14	1.91	4.11	+2.20	14 yes
3	23 / 23	2.03	4.61	+2.58	21 yes; 2 partly
4	31 / 32	2.18	4.59	+2.41	28 yes; 3 partly; 1 blank
5	17 / 17	2.38	4.69	+2.31	16 yes; 1 partly

4.2. Participant feedback

Across modules, participants moved from broad uncertainty to more precise technical questions. In Design Thinking they became better able to separate a problem, idea, goal and solution. In 2D fabrication they shifted from general concern about tools to power, speed, material thickness and drawing feasibility. In 3D work they began naming Onshape, print preparation, STL, slicing and accurate spatial modelling. In electronics they identified the connection between code and circuit behaviour. In materials they linked smart-material concepts to visible reactions and product uses.

4.3. Facilitator observations

- Learners engaged most strongly when explanations were short and immediately followed by a visible or tangible task.
- Small teams and mentoring supported varied starting levels and made it easier to intervene when learners became stuck.
- A quick early success – a structured worksheet, cut element, tag model, illuminated LED or visible material reaction – built confidence.
- The most difficult learning step across fabrication modules was converting an idea or sketch into a technically feasible object under real material, machine or print constraints.
- Documentation and presentation tasks strengthened communication as well as technical learning.
- Resource and safety requirements increase when several teams need machines, components or heat-processing equipment simultaneously.

4.4. Impact on skills development

Skill area	Skills developed	Evidence in the module reports
Project and methodological skills	Problem framing, goal definition, ideation, morphological analysis, requirements and iteration	Module 1 worksheets, sketches, cardboard models, presentations and +3.08 mean gain
2D digital fabrication	2D/3D relationships, pattern design, dimensioning, laser preparation, cutting and engraving	Module 2 fabricated elements, technical feedback and +2.20 mean gain
3D design and fabrication	CAD, Onshape, STL, slicing, printability, spatial reasoning and additive manufacturing	Module 3 models, file preparation, printing demonstrations and +2.58 mean gain
Electronics and interaction	Microcontrollers, sensors, actuators, circuits, voltage, simple code and testing	Module 4 circuits, seminar documentation and +2.41 mean gain
Materials and sustainability	Recycled/recyclable materials, smart response, heat forming, reuse and product application	Module 5 experiments, recycled objects and +2.31 mean gain



Skill area	Skills developed	Evidence in the module reports
Transversal skills	Teamwork, communication, presentation, documentation, confidence and reflective problem-solving	Team assignments, open feedback, facilitator observations and personal-progress responses



5. Best Practices and Challenges

5.1. What worked well

Best practice	Evidence across modules	How to use it
Short explanation, rapid practice	Reported in all five modules; especially strong when the result was immediately visible	Limit theory blocks and move quickly to a task, test or demonstration
Concrete starter examples	Everyday problems, 2D assemblies, a tag model, an LED and UV/heat reactions reduced abstraction	Prepare simple starter artefacts and examples before open-ended work
Small teams and mentoring	Supported different levels and enabled timely correction	Plan facilitator capacity and team sizes around equipment
Visible outputs	Models, cut parts, circuits and transformed materials increased engagement	End each learning unit with a tangible or clearly demonstrable result
Iteration and open discussion of error	Idea revision, laser tests, printability checks and debugging made constraints teachable	Treat error as evidence for refinement and document changes
Structured documentation	Worksheets and seminar assignments helped learners explain function, process and results	Provide lightweight templates for design and technical documentation

5.2. Identified challenges

- Wide variation in previous experience, including learners with no prior exposure to Design Thinking, CAD, laser preparation, programming or smart materials.
- Difficulty converting a broad idea or sketch into dimensions, technical geometry, a printable model, a circuit or a safe material process.
- Need for additional time for laser test cuts, CAD support, slicing, debugging, material preparation and cooling.
- Shorter attention spans made extended theory less effective than demonstrations and mini-tasks.
- Limited machines, electronic components or supervised heat-processing capacity can constrain simultaneous teamwork.
- Safety supervision and clear instructions are essential around lasers, electronics, tools, heated plastics and hot components.
- Aggregate questionnaires without anonymous matching identifiers limit the strength of pre/post conclusions; Module 4 also has unequal response counts.

5.3. Effective assessment tools

Assessment tool	What proved useful	Recommended refinement
PRE/POST self-assessment	Consistent five-point scale revealed perceived development in each module	Repeat identical competence items and add anonymous pairing identifiers
Personal-progress question	Simple yes/partly/no item achieved high completion and confirmed participant perception	Retain and add one short explanation field
Open responses	Explained technical uncertainties and the shift towards more precise challenges	Ask what helped most and what remained difficult
Facilitator observation	Captured tool use, teamwork, independence, misunderstanding and visible progress	Use a short shared observation checklist
Practical outputs	Worksheets, sketches, cut parts, CAD files, circuits and fabricated material objects showed application	Define a small set of module-specific output criteria
Documentation/presentation	Required learners to explain purpose, process, equipment and results	Provide concise templates and include peer feedback where feasible



6. Stakeholders Report

6.1. Available evidence and limitations

The five supplied module reports document delivery with secondary-school groups at Gimnazija Matija Mesić in Slavonski Brod, Gimnazija Nova Gradiška and a FabLab delivery venue in Slavonski Brod. They contain participant feedback and observations by the FabLab delivery team. They do not contain a separate company survey, formal policymaker consultation, tandem-partner evaluation, residency-visit report or external stakeholder scoring. This section therefore reports only the stakeholder implications supported by the implementation evidence and does not present missing activities as completed.

6.2. Key insights for policymakers and regional innovation stakeholders

- Support FabLabs and similar training organisations as mobile or place-based brokers that can bring digital-fabrication learning into schools and communities outside major urban centres.
- Fund modular, low-threshold workshops that combine immediate practical outcomes with pathways into deeper project work.
- Provide adequate facilitator time, equipment access, consumables and safety capacity; these are recurrent implementation constraints rather than optional extras.
- Support shared digital infrastructure for examples, worksheets, files, feedback and learner progress so face-to-face delivery can continue between meetings.
- Encourage school-FabLab partnerships that combine technical skills with confidence, teamwork, documentation and problem-solving.
- Use consistent, short assessment instruments with anonymous identifiers to strengthen evidence while keeping completion rates high.

6.3. Residency visits and external evaluation

As part of the evaluation process, PP6 exchanged information with its tandem partner PP3 during the pilot phase, sharing plans and initial feedback from attendees online. During the intensive pilot implementation, PP6 involved teachers to observe the process and provide their opinions, which were positive regarding the methodology. However, they also expressed the view that such a methodology is not feasible within the regular curriculum due to rigid syllabi, and that for the time being it should be offered as an optional activity, in cooperation with FabLab's and similar organisations that already apply this kind of methodology.

6.4. Relevance for regional and EU-level uptake

The PP6 pilot aligns with the DiSTT objective of using FabLab's and training organisations to address digital-fabrication skill gaps through adaptable re- and upskilling. Its main transferable feature is not a single technology but a delivery pattern: local face-to-face engagement, short explanations, rapid practical application, mentoring, visible outputs and simple evaluation. The five modules can be used independently and adjusted to local learner needs, equipment and time.

For wider uptake, the Toolkit should make the required preparation explicit: facilitator competences, sample materials, equipment and consumables, safety procedures, starter files, worksheets, expected outputs, assessment items and adaptation options. The PP6 experience is especially relevant to organisations seeking to reach secondary-school learners and communities with geographical or other access barriers.



7. Conclusion and Next Steps

PP6 implemented five independent modules covering idea development, 2D fabrication, 3D design and printing, electronics and smart interactions, and innovative materials. The source records document 109 modular participations and 27 live meetings. Every module showed a clear increase in aggregate self-assessment, and qualitative evidence consistently favoured practical, mentored and example-led delivery.

The strongest cross-module lesson is that technical learning becomes meaningful when a learner can connect an idea to a visible result while understanding the constraints between them. A worksheet, laser-cut part, CAD model, circuit response or transformed material provides a concrete anchor for explanation, iteration and confidence. The modular structure also suits outreach in schools and geographically dispersed communities.

7.1. Improvements for future re/upskilling delivery

- Create shared starter galleries, templates and short videos for problem framing, laser files, CAD operations, circuit/code examples and material experiments.
- Add small differentiated tasks so learners with different starting levels can progress without leaving beginners behind.
- Protect more time for test cuts, CAD mentoring, printability review, debugging, material preparation, cooling and reflection.
- Plan equipment, consumables, components, safety supervision and facilitator-to-team ratios before recruitment.
- Use a shared digital folder or learning space for submissions, comments, examples and revision history.
- Retain PRE/POST assessment but repeat identical questions, use anonymous pairing identifiers and add one brief question on what helped most.
- Use a simple facilitator observation checklist and module-specific criteria for practical outputs.

7.2. Inputs for further implementation (A3.3)

The five translated module designs can feed directly into the Digital Skills Transformation Toolkit as adaptable programme components. Each component should include purpose, target group, duration, delivery sequence, facilitator preparation, equipment and materials, safety requirements, starter examples, learner outputs, PRE/POST questions, observation criteria, common challenges and adaptation options.

For transfer, the Toolkit should preserve the modules' independent nature while showing optional pathways between them. Module 1 can support clearer problem and project framing; Modules 2 and 3 provide complementary fabrication routes; Module 4 adds behaviour and interaction; and Module 5 strengthens material awareness and sustainability. These are optional connections for adopters, not prerequisites that were imposed in the PP6 pilot.

Further evidence should document any tandem observations, residency visits, external stakeholder feedback and longer-term learner follow-up in a consistent format. This will strengthen the Toolkit's transferability without overstating what the current five module reports demonstrate.