

Deliverable 4.1

Handbook for STEAM Trainers



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Abstract	This Handbook for STEAM Trainers is a practical professional development resource developed within WP4 of the STEAM Innovation Ecosystem project. It is addressed to trainers, educators, and facilitators delivering STEAM learning activities across the project's three disciplinary modules: Learning STEAM Through Theatre (Science View), Learning STEAM Through Music (Inquiry Fuse and Materahub), and Learning STEAM Through Making and Tinkering (NUCLIO), along with the Mentorship Programme. The handbook provides the pedagogical grounding, facilitation strategies, lesson plan guidance, case studies, and mentorship tools needed to design and deliver integrated STEAM learning experiences in formal and non-formal settings.
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1. Introduction

1.1. Executive summary of the Handbook for trainers

This Handbook for STEAM Trainers is addressed to the trainers, educators, and facilitators who have delivered, or who will deliver, STEAM learning activities within the project's three disciplinary modules: Learning STEAM Through Theatre (Science View), Learning STEAM Through Music (Inquiry Fuse and Materahub), and Learning STEAM Through Making and Tinkering (NUCLIO).

This handbook is distinct from the Modular STEAM Educational Curriculum (D2.3), which provides the student-facing lesson plans, activity sequences, and learning materials. This document operates at a different level: it speaks directly to the trainer. It provides the theoretical grounding, facilitation strategies, practical lesson plan guidance, real implementation examples, and case studies that a trainer needs to deliver and adapt STEAM learning experiences confidently, in formal or non-formal settings, across different age groups, and beyond the life of the project itself.

The handbook is organised in four main sections. Section 1 introduces the project's pedagogical foundations, Inquiry-Based Science Education and Design Thinking, and the five core principles that underpin all three modules, followed by a summary of how the modules were implemented across the four partner countries during WP3. Section 2 provides module-specific guidance for each of the three disciplines, including the Feel → Imagine → Create → Share facilitation framework, selected lesson plans drawn directly from D2.3, and case studies from real national implementations in Greece, Cyprus, Italy, and Portugal. Section 3 addresses the Mentorship Programme in depth, offering step-by-step guidance for trainers on how to design and run a mentorship programme, what mentors need to know, how the project development criteria can be used to guide student teams, and examples of how the mentorship process unfolded in each partner country. Section 4 draws conclusions and reflects on what the STEAM Innovation implementation demonstrated about the potential of arts-integrated STEAM education.

Across all four partner countries, the project reached more than 700 students and over 100 teachers during the school year 2025–2026, producing theatrical performances, original music compositions, data sonification projects, and maker prototypes that were presented at public

showcase events, national festivals, and, through the selection process documented in this handbook, at the transnational STEAM Innovation festival in Matera, Italy, in September 2026. The diversity of contexts, from a primary international school in Nicosia to a geographically dispersed network of 27 school teams across 13 regions of Greece; from a state secondary school in Paphos serving students from migrant backgrounds to an accredited teacher training programme reaching 56 teachers across 11 schools in Portugal, demonstrated that the D2.3 curriculum is genuinely flexible, scalable, and adaptable to a wide range of educational realities.

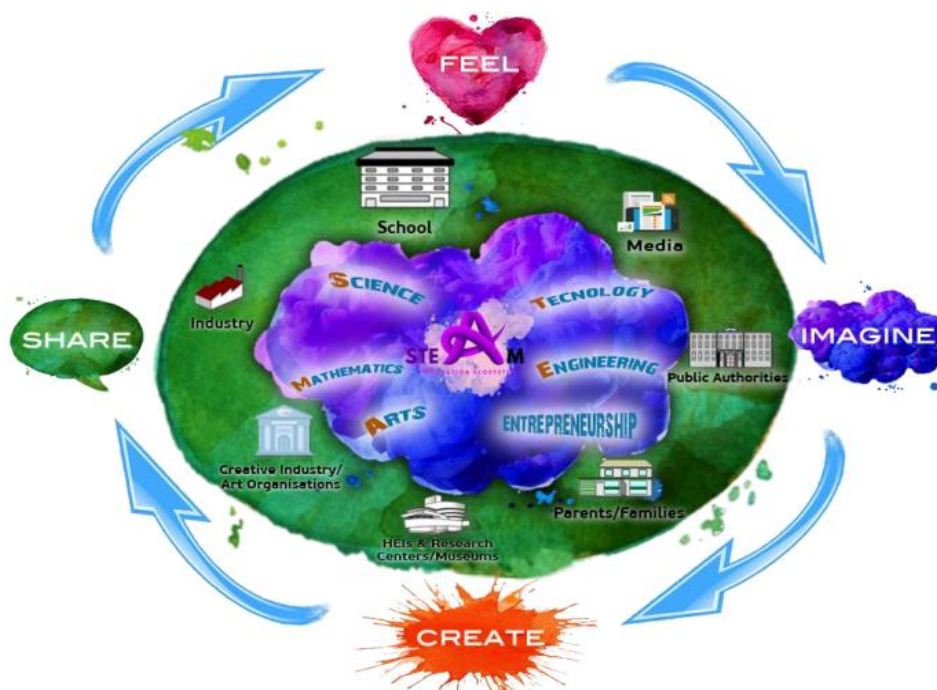
The central argument of this handbook is that STEAM education achieves its fullest potential when science and the arts are treated not as parallel activities but as genuinely integrated modes of inquiry, when students are positioned as creators rather than recipients, when learning is connected to real communities and real challenges, and when trainers are equipped not merely with lesson plans but with the pedagogical understanding and facilitation skills to bring those plans to life. This handbook is designed to be that equipment.

1.2. The pedagogical foundation: Design Thinking and Inquiry-based learning

The STEAM Innovation project's methodology, as established in the Educational and Methodological Blueprint (D2.2), rests on two integrated frameworks that together create an 'ideas become reality' mindset for STEAM education:

- Inquiry-Based Science Education (IBSE): a student-centred pedagogical model in which learners pose questions, gather evidence, analyse findings, construct explanations, and communicate conclusions, much as scientists do. Inquiry-Based Science Education places students as active investigators rather than passive recipients.
- Design Thinking (DT): a solution-oriented creative process that structures students' work through four phases, FEEL→ IMAGINE→ CREATE→ SHARE, aligned with the Double Diamond model of the British Design Council. These four phases are embedded in all three discipline modules and provide the common spine that connects Theatre, Music, and Making & Tinkering.

The FEEL → IMAGINE → CREATE → SHARE cycle,



What each phase means in practice

- **FEEL (Question + Evidence):** Students identify real problems, pose questions, and gather evidence. Teachers facilitate dialogue rather than directing. This phase is frequently underestimated, invest time in it.
- **IMAGINE (Analyse + Explain):** Students analyse their findings, map creative possibilities, and develop concepts. The teacher shifts to facilitator: coordinating discussion, challenging assumptions, encouraging brainstorming.
- **CREATE (Connect):** Students produce their artistic artefact, a theatrical performance, a musical composition, or a maker prototype. Iteration and experimentation are expected and celebrated. Failure is part of learning.
- **SHARE (Communicate + Reflect):** Students present their work to real audiences, classmates, community members, parents, CCI professionals, and ultimately at local or transnational festivals. Reflection is structured and evidence-based.

1.3. The STEAM Innovation approach: Five core principles

As defined in D2.2, the STEAM Innovation approach rests on five principles that apply across all three STEAM Innovation modules. Trainers should keep these in view when designing and delivering sessions:

No.	Core Principle	Description
1.	Inquiry-based learning integrated with Design Thinking	The pedagogical approach blends structured inquiry (IBL) with the creative, iterative mindset of Design Thinking. Students are both investigators and makers.
2.	Incubator methodology	The project follows a Train → Mentor → Create → Disseminate cycle. Learning is not an end in itself, it leads to a publicly shared artistic product.
3.	Sustainability and cultural heritage	Student projects connect scientific inquiry to environmental issues and local cultural heritage. These are not decorative themes but core content dimensions.
4.	Intercultural and inclusive approach	Activities are designed to be accessible to all learners regardless of background, ability, gender, or socioeconomic status. At least 60% of participating students come from underrepresented or marginalised groups.
5.	Creative, digital, and green competences	Across all modules, students develop critical and creative thinking, digital literacy, entrepreneurial skills, and environmental awareness, the competence profile identified in D2.2.

1.4. Summary of the Implementation activities (WP3)

Greece

The implementation in Greece took place within the national framework of the Learning Science Through Theater initiative and the STEAM Innovation project, coordinated by Science View. Schools from different educational levels and geographical areas participated, including primary schools, junior high schools, lyceums, a music school, and a special vocational education and training school. In total, the Greek implementation involved 27 school teams from 13 regions of Greece, with more than 600 students and 100 teachers participating in the creation and presentation of theatrical STEAM projects. The work was supported through a structured mentorship programme, including three interactive teacher workshops on 10 December 2025, 28 January 2026, and 25 February 2026, each with more than 30 participating teachers, as well as 15 one-to-one mentoring meetings with school units, mainly via Zoom, involving teachers and, in many cases, students. The final student projects were presented through the Learning Science Through Theater Festival 2026, both live in Athens and online, allowing schools from across Greece to share their work with a wider audience.

The main module implemented was the Learning STEAM Through Theater Module of the D2.3 Modular STEAM educational curriculum, adapted to the Greek school context and connected with the established LSTT methodology. The module was implemented through theatrical play, script writing, storytelling, music, movement, visual expression, digital media, and student-led production. Notable adaptations included the flexible use of the methodology across different school levels, the integration of local school priorities and curriculum topics, the use of online mentoring to support geographically dispersed schools, and the inclusion of diverse artistic formats such as live music, choreography, humour, AI-supported music, video production, robotics demonstrations, and digital storytelling. Overall, the implementation demonstrated that the D2.3 curriculum could be applied in a highly creative and inclusive way, supporting students not only to understand scientific concepts but also to transform them into meaningful narratives, performances, and public communication products. The overall impression was very positive: teachers and students engaged actively, the performances showed strong scientific and artistic diversity, and the process strengthened collaboration, creativity, confidence, communication, and student agency.

Cyprus

The implementation in Cyprus took place within the national framework of the Learning STEAM Through Music module of the STEAM Innovation project, coordinated locally by Inquiry Fuse. Two schools from different educational levels and districts of the island participated: Pascal International School in Nicosia, a private school engaging Year 5 upper primary students, and the Secondary School of Panagia Theoskepasti in Paphos, a state secondary school located in an isolated area where the majority of students come from migrant backgrounds and have fewer opportunities to participate in projects of this nature. In total, the Cyprus implementation involved 9 student teams across the two schools, with 36 students and 7 teachers participating in the creation and presentation of music and audiovisual STEAM projects. The work was supported through a structured mentorship programme, including three full-day interactive teacher workshops held on-site at the participating schools during the school year 2025–2026, as well as continuous weekly support provided from January through May 2026 through online meetings, on-site school visits, and one-to-one sessions with teachers, with at least five individual sessions and five school visits conducted per school throughout the implementation period. The final student projects were presented through two public showcase events: "The Sound of science, students transform data into music", held at the Paphos Municipality Hall for the secondary school students, and "Show Must STEAM On", held at Pascal International School in Nicosia for the primary school students.

The main module implemented was the Learning STEAM Through Music Module of the D2.3 Modular STEAM educational curriculum, adapted to the Cyprus school context and to the specific age groups, disciplinary backgrounds, and available digital infrastructure of each participating school. The module was implemented through two distinct but complementary approaches. At secondary level, students engaged with data sonification, the systematic translation of real-world datasets into musical compositions, using tools including Chrome Music Lab, BeepBox, BandLab, Suno, Audacity, Canva, and Adobe Illustrator, and in one case developing an original Python programme to generate MIDI files directly from Excel data. At primary level, students explored natural phenomena through original music composition, choreography, sign language poetry, and live visual art, producing performances that expressed the scientific and sensory qualities of solar eclipses, volcanic eruptions, thunderstorms, tsunamis, and ocean waves. Notable adaptations included the design of two entirely different methodological pathways for the two age groups, the integration of AI-assisted composition tools alongside hands-on physical experiments, the use of weekly online

and on-site mentoring to maintain momentum across a five-month implementation period, and the creation of a fully scripted theatrical showcase at primary level that wove five individual scientific performances into a single collective narrative.

Overall, the implementation demonstrated that the D2.3 curriculum could be applied in a flexible, inclusive, and technically ambitious way, supporting students not only to understand scientific and mathematical concepts but also to transform them into original musical works, audiovisual experiences, and public performances. The overall impression was very positive: teachers from diverse disciplinary backgrounds engaged actively with a methodology that was new to all of them, students demonstrated scientific reasoning, creative confidence, and genuine artistic maturity, and the two showcase events brought the students' work before their communities in a way that gave the learning process genuine civic and cultural significance.

Italy

In Italy, the implementation of the STEAM Innovation modules focused on combining music, audiovisual creativity, sustainability, and digital experimentation to help students explore scientific and social themes in a more engaging and creative way. Following the pedagogical approach and inquiry-based structure presented in the STEAM Innovation curriculum, students took part in interdisciplinary activities that brought together sound design, artificial intelligence, visual storytelling, music composition, and collaborative creation.

Inspired by themes connected to environmental sustainability and climate awareness, the students also explored other important social challenges, including discrimination, social exclusion, economic inequality, and gender equality. Through music, audiovisual experimentation, and digital storytelling, the projects encouraged participants to reflect on contemporary social issues and to express emotions, concerns, and possible solutions through creative and artistic languages, immersive audiovisual and sound-based experience.

The activities were developed following the methodology described in Deliverable 2.3, moving through phases of reflection, imagination, creation, and communication during collaborative workshops and mentorship sessions. Students worked together to create soundscapes, edit videos, experiment with digital tools, and build visual narratives, while mentors supported them in connecting scientific concepts with emotions, creativity, and artistic expression. The process encouraged teamwork, critical thinking, digital literacy, and active participation, while giving

students the opportunity to express complex environmental concerns through artistic language.

Through the mentorship activities, students transformed scientific reflections into creative outputs capable of communicating emotions, awareness, and social messages. Natural sounds, distorted audio effects, fragmented rhythms, and visual contrasts were used to symbolically represent the tension between ecological balance and human impact on the planet. The final result became not only an artistic production, but also a shared reflection on sustainability, responsibility, and the emotional dimension of environmental crises.

Between January and April 2026, 4 training sessions and 4 mentorship activities were organised in Italy, involving between 9 and 12 teachers and around 50 students in the implementation of the modules presented in Deliverable 2.3. During these activities, participants involved in the full program developed 10 interdisciplinary STEAM projects combining music, audiovisual creativity, sustainability themes, AI experimentation, sound design, and digital storytelling. Additional mentorship and stand-alone implementation sessions were also organised in Gravina involving two other schools, more than 25 teachers, and approximately 255 students in total.

Overall, the Italian implementation showed how the STEAM Innovation modules can create meaningful interdisciplinary learning experiences where music, creativity, technology, and science naturally interact. At the same time, the activities helped students strengthen communication skills, collaboration, critical thinking, and confidence in expressing their ideas through creative and scientific approaches. The experience was particularly meaningful for both teachers and students. Teachers coming from different subjects worked together in ways that were new and stimulating, combining science, creativity, technology, music, and artistic expression throughout the activities. At the same time, students showed a high level of participation and enthusiasm, developing not only creative and technical skills, but also greater confidence in expressing ideas and discussing complex social and environmental issues through artistic languages.

Portugal

In Portugal NUCLIO implemented the Module related to Making and Tinkering in STEAM Education. As NUCLIO is an accredited teacher training center in Portugal, teachers were engaged primarily through an accredited training course. The training was divided into 25h of

onsite training and 25h of autonomous implementation with the students, supported by NUCLIO whenever needed. The 25h on-site sessions addressed the following themes:

- Design thinking and STEAM in student centered approaches
- Student assessment practices in the age of competencies and diversity: How to assess students in STEAM projects.
- Learning electronics in a simple and fun way: designing interactive electric toys reusing waste materials.
- Programming microcontrollers and using sensors in education
- 3D modelling and printing as a tool to enhance learning
- Setting up and using webstudios in schools
- Sound and video editing
- Final reflections, presentations by teachers and evaluation.

Through these sessions, teachers learned the basis of making and tinkering and planned the implementation of STEAM Innovation with their students. Mentoring sessions supported teachers in the work they did with their students. Some mentoring sessions targeted students directly.

NUCLIO organized 4 training courses following the abovementioned approach, two in the North of the country and 2 in the center. These engaged 56 teachers from 11 schools. While some teachers participated in the full 50h course, others participated in stand-alone sessions. Those implementing the full course experimented with the lesson plans of the module with their students (e.g. electronics and programming I and II and 3D printing and modelling I and II), and followed the Design Thinking approach to guide their students in developing their own maker projects combining these skills.

In total 44 teachers and over 580 students were involved in the implementation and developed STEAM projects, which can be consulted in D3.1 - STEAM project Anthology.

By the end of the implementation activities 41 teachers answered an evaluation survey, indicating a high satisfaction with the training and the project. Most teachers demonstrate satisfaction with the content and methodologies used during the activities, as well as the support given by NUCLIO. Most teachers also felt that the activities were inclusive, personalized and that their needs were met.

One important feedback from some teachers was that the activities covered a diverse range of aspects, which while for some was beneficial, for others was challenging. While the curriculum developed in D2.3 remains very relevant, the way it is delivered during future activities can be more tailored to teachers' needs.

2. Lesson plans and case studies per module

2.1 Learning STEAM through Theatre

The Learning STEAM Through Theatre module is grounded in the Learning Science Through Theatre (LSTT) initiative that Science View has coordinated since 2014 across 400 schools in Greece and more than 50 schools in 8 European countries. This established track record gives trainers access to a rich resource base, videos, scripts, music compositions, and facilitation guides, at <https://lstt.eu/yliko/>.

The module's central proposition, as articulated in D2.2, is that theatre is a technology for transmitting knowledge: students do not merely describe scientific phenomena, they embody them. The dramatification of scientific concepts through scriptwriting, directing, scenography, music, and performance help the students achieve a form of learning that is simultaneously cognitive, physical, emotional, and social.

The module contains four lesson plans spanning approximately 32–36 hours of student engagement. It is suitable for students aged 9–18 across all subject domains, and requires no specialist equipment or financial resources. The students are expected to create their own costumes, scenery, and promotional materials.

The LSTT Learning Model, what makes it work

- **Embodied learning:** students inhabit scientific phenomena with their bodies, not just their minds. The physics of a wave, the life cycle of a cell, the behaviour of molecules, all become choreography.
- **Genuine inquiry:** the scientific topic is chosen through student questioning, not assigned by the teacher. This ownership is the engine of engagement.
- **Community connection:** performances are presented to real audiences, parents, the wider school, and at the annual LSTT festival. The knowledge that real people will witness their work transforms student motivation.
- **Role specialisation:** students divide into directing, script, music production, scenography, choreography, video, sound and lighting, and promotional activities groups, ensuring every student has a meaningful, valued contribution.

2.1.1 Learning objectives

The LSTT module aims to develop students who can:

- Get interested in science and research through theatrical play
- Develop a theatrical script relevant to a scientific topic
- Understand and apply scientific inquiry skills: posing questions, gathering evidence, constructing explanations
- Communicate a scientific argument or issue through an artistic form
- Develop creative and critical thinking, teamwork, empathy, and public speaking
- Connect school with the wider community and engage parents and external stakeholders
- Develop entrepreneurial and social skills through dissemination and promotional activities

2.1.2 The Feel → Imagine → Create → Share journey in the Theatre module

FEEL	Question & Evidence	The teacher begins dialogue about a scientific topic; students generate questions. Warm-up theatre exercises (spatial awareness games, circle exercises) create psychological safety.	Ask, do not tell. Use student questions, not teacher questions, as the starting point. Run warm-up exercises fully; they establish the safe environment that makes the rest possible.
IMAGINE	Analyse & Explain	Students research the topic using the internet, library, and scientific videos. They categorise findings and create the first improvised version of the performance skeleton.	Facilitate rather than direct. Provide search guidelines. Encourage improvisation, let the first version be rough. This is where scientific accuracy meets dramatic instinct.
CREATE	Connect	Students divide into specialist groups (script, music, scenography, choreography, promotion). Each group produces its component. Inter-group collaboration ensures coherence.	Coordinate cross-group communication. Ensure scientific accuracy remains visible. Connect students with external artists, directors, musicians, and scientists where possible.
SHARE	Communicate & Reflect	Full rehearsals; public performance at school, community level, or LSTT festival. Post-	Coordinate the performance event. Facilitate post-performance reflection.

		performance: teacher observation form (post) and student questionnaires completed.	Complete the D2.3 teacher observation form (post) and collect student questionnaires.
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2.2.1 Selected Lesson Plans from the module

Lesson Plan A: Introducing theatrical approaches and choosing the STEAM Theme

Lesson Title	Introducing Theatrical approaches and choosing the STEAM theme for the performance
Module	Learning STEAM through Theatre (Science View, Greece)
Grade Level	Upper Primary and Secondary (ages 9–18)
Duration	4 hours
Learning Objectives	Students will: (1) initiate the development of a theatrical performance on a scientific topic of their own choosing; (2) experience basic theatrical warm-up and embodiment techniques; (3) practise scientific inquiry by generating questions and beginning to define a research theme; (4) begin contact with external professionals (directors, musicians, scientists) where available.
STEAM Elements	All disciplines integrated through the choice of scientific theme. The teacher guides students towards a STEAM field relevant to the curriculum (physics, chemistry, biology, mathematics, environmental science, etc.)
Cultural Heritage Focus	Quality Education. The scientific theme may connect to cultural heritage (e.g., 'How did ancient Greek engineers solve structural problems?') or environmental issues (climate change, ecosystems, biodiversity).
Materials Needed	No specialist equipment. Paper and pencils. Internet access for research. Access to LSTT resources at https://lstt.eu/yliko/ for video inspiration and examples.

FEEL Phase (60 min)	The teacher opens dialogue about a topic from the curriculum. Key facilitation principle: use the students' questions, not the teacher's questions, to define the theme. Warm-up exercises: (1) Space-filling exercise: students move continuously to fill gaps in the space; moderator varies pace with signals (1=slow, 2=faster...). (2) Friend and enemy: each student silently chooses a 'friend' and an 'enemy'; students move to stay between them. These exercises establish physical ease and group trust.
IMAGINE Phase (60 min)	Students begin discussing the scientific notion in more detail. The teacher provides resources (videos, links) to inspire the performance concept. Students should define the specific scientific topic (e.g., 'forces in physics', 'the periodic table', 'the solar system'). The teacher encourages watching example LSTT performance videos at https://lstt.eu/videos/ for inspiration.
CREATE Phase (120 min)	Teachers may arrange a visit to a science museum or theatre, or invite an artist (actor, director, scriptwriter) to visit the school. Students begin imagining their performance concept. No script yet, only initial ideas and role discussions. The teacher circulates and asks questions rather than providing answers.
Assessment / Reflection	Teacher completes D2.3 Observation Form (Pre). Students complete D2.3 Student Questionnaire (Pre), either the secondary or primary version from the D2.3 Annexes. These are baseline data for impact evaluation.
Follow-up	The Script Writing team should be identified and begin their work in the next session (Lesson Plan 2: Developing the Story). Inform the school community that a theatrical performance is in preparation.

Lesson Plan B: Developing the story, Storytelling workshops

Lesson Title	Developing the Story, Storytelling and Script development workshops
Module	Learning STEAM through Theatre (Science View, Greece)
Grade Level	Upper Primary and Secondary (ages 9–18)
Duration	8–10 hours (across multiple sessions)
Learning Objectives	Students will: (1) learn how to develop a theatrical script relevant to a scientific topic; (2) apply the Hero's Journey narrative structure to their scientific theme; (3) practise collaborative writing, revision, and peer feedback; (4) deepen understanding of the chosen scientific concept through the narrative development process.
STEAM Elements	Science (chosen topic); Arts (scriptwriting, narrative structure, character development); Technology (using digital tools for collaborative writing: Google Docs).
Cultural Heritage Focus	Creative thinking, Quality Education. Opportunity to embed cultural heritage by including characters or settings from local historical or cultural contexts alongside scientific ones.
Materials Needed	Paper and pencils or computers. Hero's Journey template (available at lsth.eu/yliko/). Google Forms or Docs for collaborative feedback between groups.
FEEL Phase (60 min)	The teacher presents storytelling opportunities through video presentations and existing LSTT scripts. Students begin using the Hero's Journey template: What is the Call to Adventure (the scientific question)? Who are the characters (scientific concepts, historical figures, natural phenomena)? What is the Challenge (the unsolved problem)?

IMAGINE Phase (90 min across 2 sessions of 45 min)	Students work in groups to develop the main plot points using the Hero's Journey template. Each session should end with groups sharing their progress and receiving brief feedback from peers and teachers.
CREATE Phase (5–7 hours)	Students develop the dialogue of the characters. The script-writing team works on language and structure; other groups (music, scenography, promotion) begin their own components, informed by the emerging script. Regular inter-group check-ins are essential: the music group needs to know the script's emotional arc.
Assessment / Reflection	The teacher collects all group scripts for review. Peer feedback using Google Forms: 'What is clearest in the script? What needs more scientific accuracy? What surprised you?' Key question: 'Does the audience understand the scientific concept from the script alone?'
Follow-up	Script Writing team follows up with all groups to finalise script and assign performance roles. Lesson Plan 3 (Music, Scenery, Dissemination) begins in parallel.

2.2.2 Case study , Theatre in Greece

Science on stage: Performance at the LSTT festival

Project case title: “Romeo² + Juliet² = Love²”

Context and school profile

The project was implemented in a music-oriented upper secondary school in Larissa, Greece, with students from the 10th and 11th grades. The participating students were approximately 15–17 years old. The project involved 13 students and 3 educators, who supported the students throughout the creative, scientific, musical, and theatrical development of the performance.

The student group took an active role in the creation of the final piece. Students contributed to the humorous introduction, direction, choreography, set design, costumes, and live musical performance. Several students also represented the team during the event, showing strong ownership of the project and active involvement in both the artistic and scientific communication process.

Scientific theme chosen

The scientific theme selected by the students was the Pythagorean theorem. The students explored how this mathematical concept could be understood and applied through a practical and imaginative situation. Instead of presenting the theorem as an abstract formula, they embedded it in a familiar dramatic scene: Romeo needs to calculate the correct length of a ladder in order to reach Juliet's balcony.

Through this approach, the students connected mathematics with problem solving, spatial thinking, and real-life application. The project helped show that mathematical knowledge can be meaningful, useful, and creatively interpreted when placed within a story.

Theatrical form

The students created a theatrical and musical adaptation inspired by the balcony scene from Shakespeare's *Romeo and Juliet*. The performance combined theatre, humour, mathematics, choreography, and live music. The title, " $\text{Romeo}^2 + \text{Juliet}^2 = \text{Love}^2$," reflected the playful connection between the romantic story and the mathematical concept.

The performance used the well-known love story as a creative framework for explaining the Pythagorean theorem. Romeo's need to reach Juliet became the dramatic problem, while mathematics became the tool that allowed the story to progress. The use of live instruments, original musical elements, movement, and theatrical adaptation gave the scientific theme emotional and artistic meaning.

Photos and student work

The project included several types of student work and dissemination material. Students contributed to the script, the set and costume design, the choreography, and the musical performance. Live music was performed with instruments including piano, violin, flute, kanonaki, lauto, and guitar, highlighting the school's musical profile and enriching the theatrical result.

The performance was also supported through communication and dissemination activities, including posters, invitations, a press release, posts on the school website, social media communication, and the school YouTube channel. Performance photos and the video of the presentation are available through the [Learning Science Through Theater event page](#), while all relevant material is available according to the project's consent and dissemination procedures. Below are some indicative photos:



Figure 1: Photos from the $Romeo^2 + Juliet^2 = Love$ project (photos by Science View)

2.2 Learning STEAM through Music

The Learning STEAM Through Music module was developed by Inquiry Fuse and MateraHub, and represents one of the most technologically innovative and pedagogically rich components of the project. It is structured in three thematic sections, each with four lesson plans: Section 1 'Sound as Art and Science', Section 2 'AI and Immersive Worlds', and Section 3 'Creation and Final Presentation'.

The module is built on a set of genuine scientific-artistic connections: frequency is pitch; amplitude is volume; timbre is waveform shape; data patterns become rhythm. Students do not merely use music as a metaphor for science; they discover that music and science share the same physical substrate. Sound IS waves. Composition IS data visualisation. Instrument design IS materials science and engineering.

As noted in D2.2, the module covers students aged 9–15 covering both upper primary and secondary level. It connects explicitly to cultural heritage, the tamburello in Italy, the laouto in Cyprus, and to environmental data sonification, where climate change datasets become musical compositions.

Key scientific-musical connections trainers must understand

- **Frequency (Hz)** = Pitch: higher frequency = higher pitch. Chrome Music Lab Oscillators makes this visible and audible simultaneously.
- **Amplitude** = Volume: the D2.3 tuning fork and rice-on-membrane experiment (Experiment #2) make this visceral before any digital tool is introduced.
- **Timbre** = Waveform shape: why a violin and a flute playing the same note sound different. Connects to instrument design and cultural heritage instruments.
- **Data sonification**: environmental datasets (temperature, rainfall, biodiversity) can be mapped to musical elements (pitch, tempo, dynamics). This is what NASA and climate scientists actually do, and students can do it too.
- **Generative AI in music** (Suno, Amper Music): opens an authentic philosophical inquiry, 'Is AI-generated music art?', that connects science, ethics, and aesthetics.

2.2.1 Trainer preparation, digital tools checklist

Module 2 uses over 20 digital tools. Trainers must spend dedicated preparation time with these tools before delivery. The following checklist is mandatory:

Chrome Music Lab	Open Song Maker, Kandinsky, and Oscillators. Spend 20 minutes composing. Verify internet speed can support whole-class simultaneous access. musiclab.chromeexperiments.com
BeepBox	Create a simple 8-bar loop. Understand how to change pitch, rhythm, instrument timbre, and tempo. Know how to export. beepbox.co
Suno / Amper Music	Generate at least one AI composition from a text prompt. Prepare the ethical discussion question: 'Is this music? Who made it?'
Tuning fork experiment	Perform Experiment #1 (tuning fork in water) and Experiment #2 (rice on plastic wrap) yourself. Know what to expect and what variables affect the result.
BandLab or Soundtrap	Create a free account. Record a simple multi-track mix. Know how to share a project link.
CoSpaces Edu or Artivive	If attempting the AR/VR section: build a simple experience before the session. Alternative: QR-code-linked audio files are an accessible substitute.
Cultural heritage instruments	Identify what local/national instrument you can bring into the conversation (tamburello in Italy, laouto in Cyprus, etc.). Prepare an audio clip and basic facts about its construction.

2.2.2 The Feel → Imagine → Create → Share journey in the Music module

FEEL	Question & Evidence	Students listen to a range of sounds, nature recordings, silence, a short clip of John Cage's 4'33", folk instruments from partner countries (tamburello, laouto). Eyes closed, they draw or write their emotional response. They then conduct two physical experiments: a tuning fork struck and placed in water (waves made visible) and the rice-on-membrane experiment (amplitude felt as movement). Students pose their own questions: <i>"How is sound made? Why does a violin and a flute sound different on the same note?"</i>	Facilitate the listening experience without explanation, play the sounds <i>before</i> introducing any vocabulary. Resist the urge to explain what students are hearing; ask instead: <i>"What do you notice? What does this remind you of?"</i> Run both physical experiments yourself before the session so you know what to expect. Budget at least 10 minutes of eyes-closed listening at the very start. This phase is the engine, do not rush it.
IMAGINE	Analyse & Explain	Students research the scientific principles behind their chosen sound theme, acoustic ecology, the physics of a cultural heritage	Introduce the sonification concept with a concrete example (NASA converts satellite data to sound, students can do this too). Facilitate mind-mapping

		instrument, or how climate data maps to pitch. They brainstorm creative approaches: <i>"How could we represent a week of rising temperatures as a melody?"</i> They create a data-to-sound mapping plan or sketch a design for an instrument they want to build. Key concepts explored: frequency → pitch, amplitude → volume, timbre → waveform shape.	of scientific concepts onto musical elements: pitch, tempo, rhythm, dynamics, timbre. Guide students toward online resources. Introduce the Chrome Music Lab Oscillators tool to make the frequency–pitch relationship visible and audible at the same moment, show it, then hand over the keyboard.
CREATE	Connect	Students compose and produce using digital tools: Chrome Music Lab Song Maker or BeepBox for basic composition; Online Sequencer or BandLab for multi-track work; Suno for AI-assisted generation (followed by critical analysis of the output). Alternatively, students build physical instruments from recycled or everyday materials, applying their knowledge of how	Support without directing. Circulate and ask: <i>"What does this sound represent scientifically? How does changing the pitch change the meaning?"</i> Facilitate the AI ethics discussion when Suno is used: <i>"Who made this music? Is this art?"</i>, this is a genuine inquiry, not just a warm-up. Ensure scientific accuracy remains visible in the students' composition notes. If a group is stuck, ask one

		material shape and density affect sound. Each creative choice should be traceable to a scientific decision.	question, do not provide the answer.
SHARE	Communicate & Reflect	Students perform or play their compositions for the class, explaining the scientific concept behind each musical choice: <i>"This rising pitch represents increasing CO₂ concentration."</i> Products are shared at local STEAM festivals and, where selected, at the transnational festival in Italy. Post-performance, students complete the pre/post questionnaires from the D2.3 Annexes.	Coordinate the sharing event. Facilitate structured peer feedback: <i>"What did you hear? What scientific story did the music tell? Did the sound match the data?"</i> Complete the D2.3 teacher observation form (post). Collect student questionnaires, this data feeds directly into D3.3 and D5.3. Celebrate the scientific accuracy alongside the artistic quality; both matter equally in the evaluation rubric.

2.2.3 Selected Lesson Plans from the module

Lesson Plan A: Discovering the magic of sound

Lesson Title	Discovering the Magic of Sound, Exploring Sound Properties Through Art
Module	Learning STEAM Through Music (INQUIRY Fuse and MateraHub)

Grade Level	Upper Primary (ages 9–12); adaptable to lower secondary
Duration	1 hour
Learning Objectives	Students will: (1) explain what sound is and how it travels; (2) identify and experience the three properties of sound: pitch (frequency), loudness (amplitude), and timbre (quality); (3) explore how sound can be used creatively as artistic expression; (4) express ideas and feelings through sound-making and listening; (5) compose a short collaborative 'sound piece' that tells a story or sets a mood.
STEAM Elements	Science: sound waves, frequency, amplitude, timbre. Music: creative sound expression, composition. Technology: optional recording using tablet/smartphone. Arts: emotional expression, creative composition, collaborative performance.
Cultural Heritage Focus	Encouraging creativity and expression through the intersection of science and art. Optional cultural connection: introduce natural soundscapes from local or partner country environments.
Materials Needed	Audio clips (nature sounds, everyday sounds; optionally a short segment of John Cage's 4'33", 'a piece where the performer doesn't play any notes, letting ambient sounds become the music'). Speakers or headphones. Simple sound-making items: bottles, paper, rubber bands, pencils, containers. Drawing paper and coloured pencils. Optional: tablet or phone with voice recorder app.
FEEL Phase (10 min)	Play a variety of short sound clips: ocean waves, laughter, thunder, ticking clocks, silence. Students close their eyes and listen. After each clip, they choose one sound that inspired them and draw a simple picture expressing their emotional or imaginative response. This establishes the link between sound and feeling before any scientific vocabulary is introduced.

IMAGINE Phase (10 min)	The teacher introduces John Cage's 4'33" in child-friendly terms. Students listen quietly to ambient sounds and reflect: 'What do I hear in the silence?' Students are then invited to imagine a place or story that a natural sound might belong to. They draw or write a short description of their imagined scene.
CREATE Phase (25 min)	Students work in small groups with classroom materials (bottles, paper, pencils, rulers, containers). Teacher provides a few examples of how these objects can make sounds (tapping, rubbing, blowing). Groups experiment with: varying PITCH (high/low), VOLUME (loud/soft), and TIMBRE (smooth, rough, echoing). Each group composes a 30–60 second 'sound piece' that tells a story or sets a mood. They give it a title.
SHARE Phase (15 min)	Each group performs their sound piece. The rest of the class listens and reflects: 'What sounds did you notice? What did this piece remind you of?' The presenting group explains how they created their sounds and what they wanted the audience to feel. Peer feedback is kind and structured.
Assessment / Reflection	Participation in listening and group work. Completion of drawing or written reflection. Simple self-assessment exit ticket: 'What did I learn about sound today?' Teacher observation of creativity and teamwork.
Follow-up / Extension	Go on a 'sound walk' around the school to record or write down interesting sounds. Create a 'class soundscape' collage. In the next lesson, move to digital tools (Chrome Music Lab Song Maker or BeepBox) to compose more structured pieces.

Lesson Plan B: Turning data into music, Sound mapping through numbers

Lesson Title	Turning Data into Music, Environmental sonification with online sequencers
Module	Learning STEAM through Music (INQUIRY Fuse and MateraHub)

Grade Level	Upper Primary and Lower Secondary (ages 9–15)
Duration	1 hour
Learning Objectives	Students will: (1) recognise and describe environmental sounds and their data contexts; (2) identify how numbers (temperature, rainfall, biodiversity) can be represented through musical sound; (3) collaborate to convert a simple dataset into a short audio piece; (4) build genuine connections between science (environmental data) and the arts (music/sound design).
STEAM Elements	Science: environmental data, wave properties. Technology: music sequencers, digital audio tools. Engineering: data-to-sound mapping. Arts: creative composition, soundscape design. Mathematics: data interpretation, pattern recognition, number-to-note mapping.
Cultural Heritage Focus	Climate Action. Using sound as a creative medium to communicate environmental information: temperature change, biodiversity loss, pollution levels. Students become 'sonic journalists' for the planet.
Materials Needed	Computers or tablets with internet access. Online Sequencer (onlinesequencer.net) or BeepBox (beepbox.co). Headphones (optional). Printed or projected datasets: hourly temperature readings, rainfall over a week, biodiversity indices. Whiteboard for mapping data-to-sound ideas.
FEEL Phase (10 min)	Open with the question: 'What does our environment sound like? And what does it sound like when it changes?' Play 4–5 short sound clips associated with environmental change: birdsong vs urban noise, healthy river vs polluted water, normal wind vs storm. Students note their emotional response and what scientific information each sound might carry.
IMAGINE Phase (10 min)	The teacher introduces the concept of sonification with a brief example: show a simple temperature dataset for a week and ask: 'If Monday was cold and Friday was hot, how might we represent

	that as a musical sequence? Higher pitch for warmer? Faster tempo for more intense days?' Students map the dataset using the 'Data-to-Sound Mapping' worksheet: choose what musical element (pitch, tempo, rhythm, dynamics) represents what data dimension.
CREATE Phase (25 min)	Students use Online Sequencer or BeepBox to build a 30–60 second piece that represents their chosen dataset. They apply their mapping decisions from the Imagine phase. Groups can divide roles: one student manages the sequencer, another checks the data, a third writes the 'liner notes' explaining what each musical choice represents scientifically.
SHARE Phase (15 min)	Each group plays their composition and presents their data story: 'This is a week of temperature in Lisbon in July. Hear how the pitch rises on Wednesday, that is the heat wave.' Peer feedback: 'What did you hear? Did the sound match the data story?' The teacher leads reflection on what music can communicate that a graph cannot.
Assessment / Reflection	Short reflection journal or exit slip: 'What was the most interesting part of turning data into music? What scientific concept did the music help you understand?' Peer feedback after each performance. Teacher observation of scientific accuracy in the mapping decisions.
Follow-up / Extension	Invite students to bring in or collect their own dataset (sound levels at recess, plant growth, water usage at home) and create a new sound sequence. Combine all group compositions into a class 'Data Symphony' and present at a school assembly or share online.

2.2.4 Case studies, Music in Cyprus and Italy

Case study in Cyprus

Project case title: “From Goals to music”, Music Python team

Context and school profile

The project was implemented at a secondary school in Paphos, Cyprus, involving students from a state secondary education setting. The school is located in an isolated area, and most of its students come from migrant backgrounds, representing a group with fewer opportunities to participate in projects of this nature. The participating students were approximately 14–16 years old. The project involved 4 students and a cross-disciplinary teaching team supported by mentors and facilitators from Inquiry Fuse throughout the creative, scientific, musical, and technological development of the final composition and public presentation.

The student group, known within the project as the Music Pythons, played an active and collaborative role throughout the entire process. Students contributed to the conceptual development of the project, the collection and organisation of real sporting data, the design of the data-to-music mapping system, the development of an original Python programme, and the creation and public communication of the final MIDI compositions. The project encouraged strong student ownership, allowing participants to transform their interest in sport and data into a rigorous, original, and artistically meaningful musical experience.

Scientific and social theme chosen

The central theme selected by the students was data sonification, the systematic transformation of numerical data into sound and music, applied to one of the most universally recognised and emotionally engaging data domains for young people: professional football statistics. The project explored how real-world sporting data, specifically the goal records of Lionel Messi and Cristiano Ronaldo across the period 2012–2025, can be translated into an original musical composition that makes the data audible rather than merely visible in tables or graphs.

Rather than approaching data analysis through traditional statistical outputs, the students used musical elements, pitch, rhythm, dynamics, timbre, and instrumentation, to represent the numerical patterns and distinctions within the data. Through this approach, the students

connected mathematical reasoning with artistic decision-making, scientific inquiry with creative expression, and technological development with cultural reflection. A deeper insight emerged through the process: students came to understand that data is never fully objective, since the assumptions and choices made during the mapping process, which instrument represents which player, which musical parameter represents which data variable, shape the final artistic outcome. Through this realisation, the project connected data science with the philosophy of science, showing how STEAM education can address complex epistemological questions through creative interdisciplinary processes.

Audiovisual and musical form

The students created a dual MIDI composition, one piece for Lionel Messi and one for Cristiano Ronaldo, generated automatically by an original Python programme developed by the students themselves, without the use of external libraries. The programme reads data directly from an Excel file and applies the mapping rules designed by the team, producing a complete MIDI composition from numerical data alone.

Each player was assigned a distinct musical identity. Messi was rendered through piano, chosen to convey the technical fluency, melodic quality, and smooth flow of his playing style. Ronaldo was rendered through electric guitar and drums, capturing his power, intensity, and explosive athleticism. Year-by-year goal totals determined pitch within the C Major scale, with the most prolific seasons reaching the highest notes. Goal types, open play, penalties, and headers, were mapped onto distinct rhythmic and dynamic elements, creating a layered musical narrative in which every sound had a traceable scientific justification.

The two compositions were strikingly different in character: Messi's piece was smooth, progressively melodic, and technically fluent; Ronaldo's was more powerful, rhythmically intense, and dynamically varied. Sound played a central role in communicating meaning, not through words or images, but through the musical logic of the data itself. The final result combined data science, algorithmic programming, music theory, and artistic interpretation into a single interdisciplinary production capable of generating both intellectual reflection and genuine aesthetic experience within the audience.

The final compositions were presented publicly at the showcase event "The Sound of science, students transform data into music", held at the Paphos Municipality Hall. Students presented

their methodology, their mapping decisions, and their critical reflections on data objectivity to an audience of peers, parents, teachers, and community members, demonstrating scientific and technological maturity and achieving the highest scores across the national festival evaluation rubric. The project was selected as one of the three Cyprus projects to represent the country at the transnational STEAM Innovation festival in Matera, Italy, in September 2026.

Photos and student work

The project included several forms of student work and dissemination activities. Students contributed to data collection and analysis, Python programme development, music mapping design, MIDI composition production, and the creation of presentation materials connected to the public showcase event. The final production was presented through the national showcase event at Paphos Municipality Hall, social media communication planned by Inquiry Fuse, and public sharing activities connected to the STEAM Innovation initiative.

The project also encouraged collaborative reflection on scientific objectivity, the relationship between data and interpretation, and the creative potential of programming and music as interconnected disciplines, demonstrating how audiovisual creativity, data science, and music can become powerful tools for communication, critical thinking, and interdisciplinary STEAM learning. Photos, videos, and dissemination materials related to the project were produced and will be shared according to the project's dissemination and consent procedures.





Figure 2: Photos from the “From goals to music” project (photos by Inquiry Fuse)

Case study in Italy

Project case title: “La Barriera Elastica – The Elastic Barrier”

Context and school profile

The project was implemented in a High School in the South of Italy, involving students from upper secondary artistic and audiovisual study pathways, including Audiovisual and Multimedia studies. The participating students were approximately 15–17 years old. The project involved 6 students and 1 educator, supported by mentors and facilitators from Materahub throughout the creative, musical, digital, and conceptual development of the final audiovisual performance.

The student group played an active and collaborative role throughout the entire process. Students contributed to the conceptual development of the project, the creation of the sound narrative, visual composition, symbolic storytelling, video editing, soundtrack selection, and dissemination activities connected to the final presentation. The project encouraged strong student ownership, allowing participants to transform personal reflections on inequality, exclusion, and identity into an immersive artistic and emotional experience.

Scientific and social theme chosen

The central theme selected by the students was social inequality and the concept of invisible barriers within contemporary society. The project explored how discrimination, exclusion, and social pressure create divisions between individuals and communities. Rather than approaching these issues through traditional verbal explanation, the students used sound, rhythm, visual symbolism, and digital audiovisual language to represent the emotional and psychological effects of inequality.

The metaphor of the “elastic barrier” became the core symbolic element of the project. Students imagined humanity as an elastic membrane stretched under the pressure of prejudice, division, and exclusion, while still maintaining the possibility of resilience, inclusion, and coexistence. Through this approach, the students connected social reflection with emotional perception, artistic experimentation, and collaborative inquiry, showing how STEAM education can address social challenges through creative interdisciplinary processes.

Audiovisual and musical form

The students created an immersive audiovisual performance combining experimental sound design, symbolic imagery, digital editing, rhythm and visual storytelling. The project did not follow a traditional narrative structure; instead, it developed as a sensory and emotional journey where fragmented sounds, distorted rhythms, abrupt transitions, and contrasting atmospheres represented tension, instability, and separation.

Sound played a central role in communicating meaning. Students experimented with fragmented rhythms, layered sound textures, moments of immersive audio transitions to symbolise emotional pressure and social fragmentation. Visual elements and digital projections were used alongside soundscapes to reinforce the sensation of barriers, instability, and emotional isolation. The final result combined music, audiovisual language, symbolic narration, and digital creativity into a single interdisciplinary artistic production capable of generating reflection and empathy within the audience.

Photos and student work

The project included several forms of student work and dissemination activities. Students contributed to sound experimentation, audiovisual editing, symbolic visual design, digital montage, and the creation of communication material connected to the presentation of the project. The final production was presented through school dissemination activities, digital presentations, social media communication, and public sharing events connected to the STEAM Innovation initiative.

The project also encouraged collaborative reflection on inclusion, identity, emotional wellbeing, and collective responsibility, demonstrating how audiovisual creativity and music can become powerful tools for communication, active citizenship, and interdisciplinary STEAM learning. Photos, videos, and dissemination materials related to the project were produced and shared according to the project's dissemination and consent procedures.



Figure 3: Photos from the “La Barriera Elastica – The Elastic Barrier” project (photos by MateraHub)

2.3 Learning STEAM through Making and Tinkering

The Making and Tinkering module, titled Change Makers, places students at the centre of a genuine entrepreneurial and civic journey. Rather than teaching technical skills in isolation, the module challenges students to identify a real local problem in their school or community, and to develop an innovative STEAM-based solution using maker methodologies. The approach is grounded in a core belief articulated in D2.2: that anyone can be a maker, as long as they bring resilience, resourcefulness, creativity, innovation, and collaboration to the task.

The module was authored by NUCLIO (Portugal) and is implemented in NUCLIO's makerspace facilities as well as in several schools throughout the country. It targets students aged 9–18 across all subject domains and spans seven modular lesson plans that can be combined as 'puzzle pieces' according to available equipment and context.

What makes the Making module distinctive

- **Community-first orientation:** students identify a real local problem before any technical skills are introduced. The maker tools serve the problem-solving goal, not the other way around.
- **Radical flexibility:** the module explicitly states that students without 3D printers, micro:bits, or special equipment can produce meaningful work using available resources such as cardboard, recycled materials, and storytelling.
- **Entrepreneurial dimension:** students are expected to 'sell' their ideas, to communicate, pitch, and consider the viability of their solution for a real audience.
- **Celebration of failure:** trial and error is built into the process and promotes resilience. Trainers should model comfort with iteration and resist the urge to provide solutions.

2.3.1 Learning objectives

Knowledge and Skills students develop:

- Digital fabrication skills: 3D modelling and printing, vector design, electronics and circuits, programming (micro:bit, Arduino, Scratch, Makecode), and Artificial Intelligence basics.
- Creativity and innovation: inventing solutions to real problems that have not been solved before.
- Resilience: continuing despite difficulties and failures, a disposition modelled and celebrated by the trainer.
- Resourcefulness: designing solutions using whatever resources are at hand, from 3D printers to cardboard.
- Collaboration and communication: working in groups, listening with respect, presenting ideas clearly.
- Active citizenship: understanding that students of any age can contribute to improving their community.

2.3.2 The Feel → Imagine → Create → Share journey in the Making module

The D2.3 module follows the seven-phase IBSE inquiry cycle embedded within the four Design Thinking phases. The table below shows how this unfolds specifically in the Making and Tinkering context, and what trainers should be doing at each stage.

FEEL	Question & Evidence	Explore local problems through observation, interviews, surveys. Ask: 'What problems affect our school or community most?' Gather evidence. Build empathy.	Inspire curiosity. Ask provocative questions about local issues. Teach research methods. Avoid directing students toward a predetermined topic.
IMAGINE	Analyse & Explain	Brainstorm solutions using 'How Might We...' questions. Map stakeholders. Identify required skills and partners. Draft a project plan or prototype concept.	Facilitate brainstorming. Introduce SWOT analysis and problem trees. Invite community stakeholders to brainstorm sessions if possible.
CREATE	Connect	Build prototypes using available maker tools and materials. Plan workflow, assign roles, test and iterate. Combine digital fabrication with recycled materials.	Support without directing. Celebrate iteration. Ensure students document their process. Connect groups to relevant experts or materials.
SHARE	Communicate & Reflect	Organise a Maker Fair or public exhibition. Present to parents,	Coordinate the sharing event. Facilitate structured reflection.

		NGOs, local authorities. Document with photos and video. Reflect on what worked and next steps.	Ensure students feel proud of their achievement.
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2.3.3 Selected Lesson Plans from the module

Lesson Plan A: Electronics I: Build an electric toy

Lesson Title	Electronics I, Exploring circuits through creative making
Module	Making and Tinkering (NUCLIO, Portugal)
Grade Level	Upper Primary and Lower Secondary (ages 9–15)
Duration	90–120 minutes
Learning Objectives	Students will: (1) understand basic electric circuits including series/parallel configurations, switches, and resistors; (2) apply circuit knowledge to build a creative functional artefact; (3) connect STEAM principles ,Science (Ohm's Law, current flow), Technology (online simulators), Engineering (building functional projects), Arts (design and decoration), Mathematics (voltage and current analysis); (4) develop skills in planning, creating, and sharing STEAM-based work.
STEAM Elements	Science: basic electric circuits, current flow, Ohm's Law. Technology: online simulators and electronic components. Engineering: building functional projects. Arts: designing and decorating the project. Mathematics: applying Ohm's Law, analysing voltage and current in circuits.
Cultural Heritage Focus	Quality Education (digital skills and innovation); Industry, Innovation, Infrastructure (creative use of tech for real-world solutions). Sustainability: reuse of components and low-power microcontrollers.
Materials Needed	Batteries, wires, resistors, LEDs, DC motors, switches, conductive tape. Recycled materials (cups, cardboard, used coffee capsules, straws, etc.). Computers with internet access. Online PHET circuit construction kit (phet.colorado.edu).

FEEL Phase (30–45 min)	Open with a video: “What is the impact of electronics in everyday life?’ Small groups discuss and map ideas. Provocation questions: “What is electricity and where does it come from?”, ‘What everyday objects use electricity? Could you make one yourself from scratch?’ Students record initial questions and assumptions.
IMAGINE Phase (30–45 min)	Students explore the Tinkercad or the PHET circuit simulator online ,building virtual circuits, testing switches, understanding resistance. The teacher introduces the project goal: We must find creative ways to reduce waste. What if it could be transformed into fun toys? Students can choose to build a painting robot, electronic postcard, or electric car using basic circuits and recycled materials. Students sketch their design.
CREATE Phase (60 min)	Students select the sketch they want to follow to build their chosen artefact using real components. Trainer circulates, prompting rather than solving: ‘Why do you think the LED is not turning on?’ “Is the circuit closed”? “Have you tried building the circuit in a different way?” “What do you think is happening when the LED goes off?’ Encourage decoration and personalisation as an artistic dimension. Document the process with photos. Allow several trial and error iterations.
SHARE Phase (30 min)	Groups present their artefact to the class: what they built, what scientific principle it demonstrates, and what they would improve. Peer feedback using ‘I notice / I wonder / What if?’ Protocol. Trainer facilitates collective reflection. Optional: Students invite families to the school and lead a workshop for them to build an electric toy. Reflection: Students reflect on the impact of their ideas and how they can be further explored to solve the problem: reduce waste.

Assessment	ASSESS rubrics for collaboration, creativity, and communication. Circuit design checklist. Functionality of the product. Student presentations and self-reflection exit ticket: 'What did I learn about circuits? What would I change?' "What do I still need to learn?".
Follow-up / Extension	Improve the project by integrating additional components (e.g., add LEDs to the car or robot). Or advance to Lesson Plan B (Electronics and Programming I) using micro:bit.
Adaptation Notes	No 3D printer or specialist equipment required. All materials can be sourced from everyday items. For students with limited dexterity, adapt the building task to focus on design and documentation. DC motors can be found inside old electric toys.

Lesson Plan B: 3D Modelling and Printing I: Design and print your own artefact

Lesson Title	3D Modelling and Printing I, From digital design to physical object
Module	Making and Tinkering (NUCLIO, Portugal)
Grade Level	Lower and Upper Secondary (ages 12–18)
Duration	3 hours
Learning Objectives	Students will: (1) understand the principles of 3D modelling and additive manufacturing; (2) use TinkerCAD to design a basic 3D object; (3) prepare a model for printing using OrcaSlicer; (4) gain awareness of real-world applications of 3D printing; (5) develop creativity, spatial reasoning, and design thinking skills.
STEAM Elements	Science: digital fabrication and material properties. Technology: 3D software and slicers. Engineering: designing functional, printable objects. Arts: visual design, personalisation, and

	creativity. Mathematics: working with dimensions, proportions, and geometry.
Cultural Heritage Focus	Industry, Innovation, Infrastructure. Responsible Consumption and Production. Opportunity to design objects inspired by local cultural heritage artefacts (e.g., design a keychain representing a traditional motif from the local culture).
Materials Needed	Computers with internet access and mouse. Tinkercad accounts (free, tinkercad.com). OrcaSlicer software (free, open-source). 3D printer and PLA filament. Projector for video tutorials. Sketch paper for planning.
FEEL Phase (45 min)	The teacher introduces 3D printing through short videos showing real-world applications: architecture, medicine, art, environmental engineering. Discussion: 'What kind of objects could you create or improve with 3D printing?' Students reflect: 'What would I design if I could make anything?'
IMAGINE Phase (30 min)	Students brainstorm and sketch a personalised keychain (or object of their choice). They consider: size, shape, text elements, cultural or personal meaning. The focus is planning: what does the object look like? What does it mean to the student?
CREATE Phase (60 min)	Students use Tinkercad to build their design. Trainer supports navigation of basic tools (shapes, resize, text, hole). Once models are complete, students export and open in OrcaSlicer. Trainer demonstrates slicer settings (infill, supports, material) and generates G-code for printing.
SHARE Phase (45 min)	Trainer demonstrates loading filament, preheating, and starting the print. Students observe. When prints are ready (or in subsequent sessions), each student presents: 'What did I design? What science or engineering principle does it involve? What would I change?' Open class discussion on the process.

Assessment	Observation of engagement during modelling. Review of completed digital model and printed object. Self-assessment: 'What was the hardest part? What did 3D printing teach me about design?' Peer gallery walk with sticky note feedback.
Follow-up / Extension	Design a functional object (cable holder, badge, sustainable packaging model). Combine with electronics: 3D-print an enclosure for a micro:bit circuit.
Adaptation Notes	If no 3D printer is available: students complete the TinkerCAD design phase and present their digital model, explaining what they would print and why. The design process alone has strong learning value.

2.3.4 Case study ,Makerspace in Portugal

As described in section 1.4. NUCLIO implemented the Making & Tinkering module with 11 schools throughout Portugal. Here one case study is highlighted, related to the implementation in one school: Agrupamento de Escolas de Pinhel. From December 2025 to April 2026 17 teachers participated and completed the 50h professional development course (as described in section 1.4), developing 4 STEAM projects with 228 students from 5th to 12th grade.

The themes of the projects were:

- **The bottle catcher:** A prototype of a scale using weight sensors, a microcontroller and acrylic plates to measure the weight of plastic waste produced by water bottle consumptions. The goal is to turn this prototype into a real-life initiative to raise awareness in the school for the amount of plastic waste and, ultimately, reduce it. This project integrated concepts from Geography, Citizenship and Development and ICT.

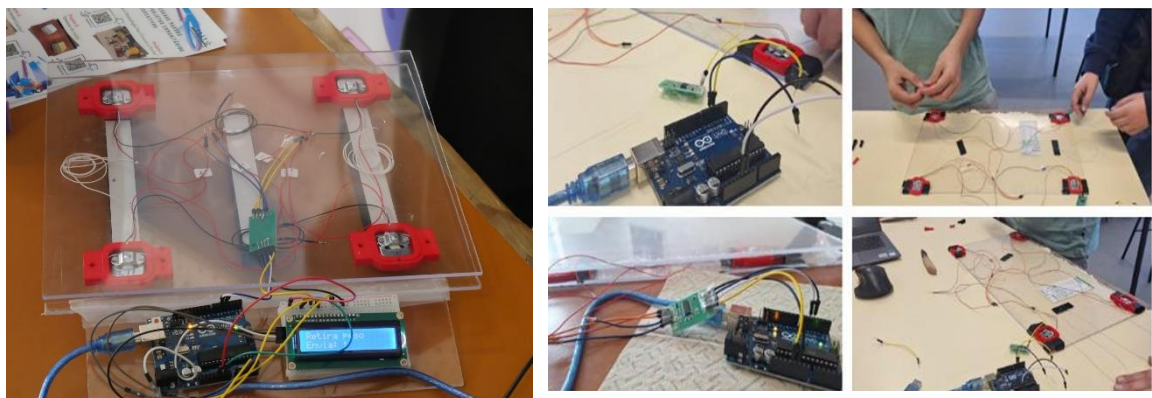


Figure 4: Bottle catcher scale being designed by the students

Students showed strong engagement throughout, and visible enthusiasm in many moments. For instance when the scale prototype first started giving accurate weight readings, one teacher described the reaction as a clear sense of "this actually works." The project also promoted inclusive participation, with different students contributing according to their strengths: some in the technical assembly and Arduino programming, others in 3D modelling or problem-solving, and some typically quieter students finding visibility during the load cell calibration phase. Students were also excited by the possibility of presenting the project at a national event, with the chance of representing Portugal in Matera, Italy. The main challenge was the technical complexity of building the scale circuit, which required significant iteration and troubleshooting. This was addressed through continuous feedback, peer support, and a trial-and-error approach. In the following school year, the prototype will be upgraded into a

fully functional Bottle Catcher system for the whole school, monitoring plastic waste consumption and raising awareness across the entire school community.

- **Sound pollution detector in the school:** A prototype with a microcontroller and a sound sensor with a mechanism of bluetooth communication to a similar prototype to be stored within the principal's office. The goal is to control noise pollution in the school common areas and to alert the principal in case action is needed. Students and teachers used 3D modelling and printing to design the cases for the sensor. This project integrated concepts from Natural Sciences, Physics and Chemistry; Mathematics; Design, communication and Audiovisuals; Informatics and Citizenship and Development.



Figure 5: Final sound detector prototype developed by the students

Students realised the school was much noisier than they had assumed, and measuring it themselves made that concrete. One student's reaction became recurrent across classes: "I never realised the school was this loud until we measured it with the sensor," and one teacher described the moment students connected their own behaviour to the decibel spikes as the point "where science became social conscience." The project promoted inclusive participation, with different students contributing according to their strengths: some in programming, others in 3D modelling of the sensor cases, circuit assembly, or data analysis. The main challenges were in the technical assembly of the circuits and in calibrating the sound thresholds across different spaces, which required significant iteration and adjustment. These were addressed through continuous feedback, peer support and trial-and-error. In the following school year, the prototype will be upgraded into a fully functional noise monitoring system with Bluetooth communication to a device in the principal's office, enabling real-time alerts when noise levels in common areas require intervention.

- **Where technology can help the green to grow:** A prototype of an automated irrigation system to water the school plants during the night. The goal was to design a solution to reduce water waste in the school and to promote the use of renewable energies. Students programmed a microcontroller and designed all the necessary circuits for a small-scale irrigation system. They used 3D modelling and printing to design the structure for their prototype. This project integrated concepts from ICT; Hydrostatic Physics and Hydrodynamics; and Multimedia.

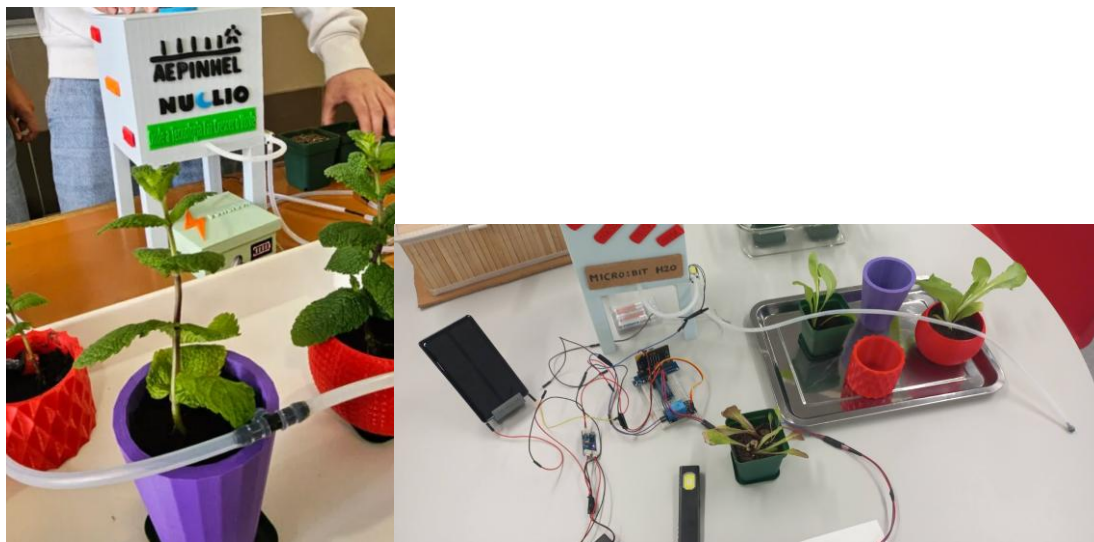


Figure 6: Final prototype of the automated irrigation system developed by the students

Students showed strong engagement throughout, with visible enthusiasm in many moments. For instance when the system first ran entirely on solar energy, and when the 3D-printed parts were completed. Despite having no prior experience with micro:bit programming, students worked through technical difficulties by quickly becoming autonomous, using trial-and-error and peer support. One of the most valuable aspects of the project was cross-age collaboration between 6th and 11th grade students, and not always with the older ones leading. The project also gained unexpected reach when a visiting Erasmus+ group of Italian students in the school showed strong interest in the project. The main challenge was the students' lack of familiarity with micro:bit, which required teachers to adapt lesson plans in the middle of the project. This was addressed by keeping formal instruction brief and letting experimentation and collaboration between students drive the learning process

- **Electromagnetize yourself “From the digital laboratory to the real world”:** This project was born from a collaboration between students from 5th, 9th, 10th and 11th grades and focused that originated from the question: “what are the impacts of electromagnetism, from

5G to everyday communications". Students designed an activity kit with hands-on experiments related to electromagnets, simple circuits, old motors, 3D printing and experimental testing with trial and error. This project integrated concepts from Physics and Chemistry; Mathematics; Citizenship and Development and ICT.

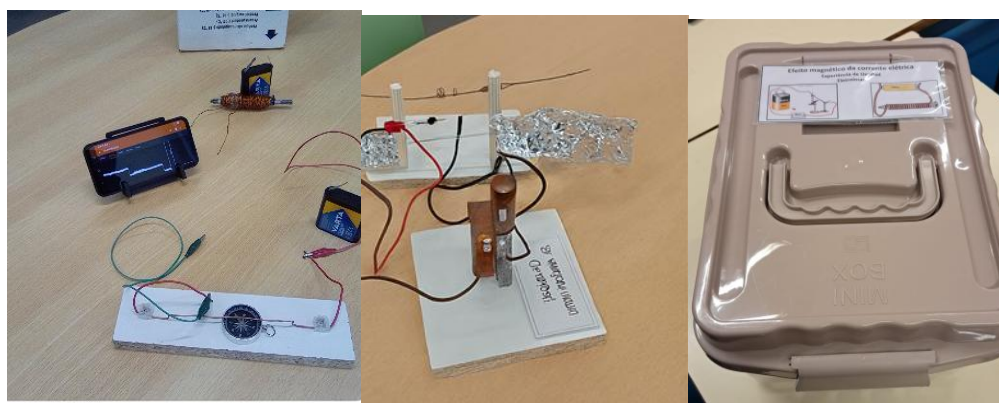


Figure 7: Work in progress and final hands-on activity toolkit developed by the students

One of the most visible outcomes was the genuine curiosity students brought to the project from the very start. For instance, a 5th grade student asked "If Wi-Fi goes through walls, could light do the same?". The project promoted inclusive participation, with students from different year groups contributing according to their knowledge: some in circuit assembly and motor construction, others in 3D printing, disassembly of old electronics, and data analysis with the Phypox app. Older students took on the role of workshop specialists while younger ones brought fresh questions that helped move the project forward. The project also reached beyond the classroom, with the community contributing old electronic equipment for disassembly and the final kits being shared with the school's science club. The main challenge was managing the complexity of building working circuits and motors across such different age groups and disciplines, which required continuous adjustment of lesson plans and significant trial and error. This was addressed through peer support, iterative feedback, and a hands-on trial and error approach.

These projects integrated cultural heritage in STEAM education by encouraging students to creatively address real-world challenges through technology, collaboration, and hands-on experiences. By promoting sustainable practices, collective responsibility, and collaboration, the projects contributed to the development of active citizenship and to the preservation of social, environmental, and educational values that are part of both local and contemporary cultural heritage.

3. Mentorship programme

3.1 Methodology

The mentorship programme follows a student-centred and interdisciplinary methodology that places students at the core of the entire creative and learning process. Rather than being passive recipients of knowledge, participants are encouraged to actively explore, experiment, collaborate, and reflect throughout the development of their projects. The methodology combines practical experimentation, collaborative creation, artistic expression, and personalized mentoring support in order to create an inclusive and dynamic learning environment where creativity and innovation can emerge naturally. Through continuous interaction with mentors, educators, artists, and professionals from the Cultural and Creative Industries, students are exposed to real working practices and are encouraged to connect scientific thinking with artistic approaches and social awareness. The mentorship activities also built upon the experiences and competences developed by students during the previous STEAM project activities implemented within Tasks 3.1–3.3, allowing participants to further apply and expand their knowledge through practical and interdisciplinary experimentation. A strong emphasis is placed on learning through practice. Students are encouraged to test ideas, make mistakes, discuss solutions together, and gradually improve their projects through experimentation and collaboration. Workshops, rehearsals, laboratories, makerspace activities, and collaborative sessions provide opportunities for students to transform ideas into concrete outputs while developing technical, artistic, digital, and interpersonal competences. The integration of digital technologies and multimedia tools also supports students in exploring new forms of communication, storytelling, production, and creative expression. At the same time, the programme encourages participants to reflect on important contemporary themes such as sustainability, inclusion, innovation, emotional wellbeing, and entrepreneurship, promoting a broader understanding of the social impact of creativity and STEAM education. The mentorship process combines collective activities with individual and small-group guidance, ensuring that each participant receives continuous support according to their interests, skills, and creative aspirations. Mentors accompany students throughout the various stages of project development, offering constructive feedback, professional orientation, and encouragement for experimentation and critical reflection. Alongside the students, teachers are also actively involved in the mentoring process. Experts and creative professionals work closely with educators, providing them with practical guidance, methodological tools, and

hands-on experience so that they can progressively become confident in independently applying the STEAM methodology with future classes and educational activities. In several activities, teachers participated directly alongside students during workshops and rehearsals, experiencing the methodology from both the learner's and facilitator's perspective. In this way, the programme not only supports the immediate implementation of the mentorship activities, but also contributes to the long-term sustainability and transferability of the methodology within schools and educational contexts.

The programme particularly focuses on:

- STEAM through Theatre;
- STEAM through Music;
- STEAM through Making and tinkering (Makerspaces).

3.2 Structure of the mentorship programme

The mentorship programme is developed over a period of approximately five months and is structured as a dynamic and collaborative educational pathway that combines creative experimentation, practical learning, and continuous mentoring support. The programme is organised through a combination of:

- Group workshops
- Practical laboratories;
- Mentoring meetings;
- Collaborative project sessions;
- Visits to creative and cultural spaces;
- Public presentations and dissemination activities.

Throughout the programme, students are progressively guided from the initial exploration of ideas to the development and presentation of final creative outputs. Activities are designed to encourage active participation, interdisciplinary thinking, teamwork, and problem-solving, while also giving students the opportunity to engage with real creative processes and professional practices. The mentorship pathway combines artistic experimentation with scientific inquiry, allowing participants to explore how different STEAM disciplines can interact

through theatre, music, audiovisual production, digital technologies, and makerspace activities.

A central aspect of the programme is the continuous exchange between students, teachers, mentors, artists, and creative professionals. Many activities were organised in mixed working groups where participants could share ideas, test solutions together, and learn from each other's experiences. Through workshops, rehearsals, laboratories, and project-based activities, participants are encouraged to co-create, share ideas, and develop innovative solutions in a supportive and inclusive environment. The programme also includes visits to theatres, cultural centres, makerspaces, music laboratories, and creative hubs, offering students direct exposure to professional environments and creative careers.

In parallel, teachers participate actively alongside students throughout the mentorship process. Experts and mentors provide educators with methodological support, practical tools, and opportunities for co-facilitation so that they can gradually acquire the confidence and competences needed to independently implement similar STEAM activities with future groups of students. This collaborative approach contributes to strengthening the long-term impact and sustainability of the methodology within schools and educational institutions.

The activities are organised to ensure that participants can experiment, create, prototype, rehearse, reflect, and present their ideas within authentic and stimulating learning environments where creativity, innovation, and social awareness are continuously encouraged.

3.3 Guidelines for Trainers: How to organise a mentorship programme

Step 1: Identify and recruit mentors

Mentors should be drawn from the expert networks established during WP2 (T2.2 expert consultations). Each partner country should seek mentors across the three discipline areas (theatre, music, making) and the broader CCI landscape (digital arts, cultural heritage, entrepreneurship).

- Profile of an effective mentor: professional expertise in a STEAM-relevant field; genuine interest in working with young people; willingness to give structured, constructive feedback; availability for at least 3 sessions over 5 months.
- Diversity matters: actively recruit women mentors, mentors from cultural minority backgrounds, and practitioners from non-traditional STEAM fields. Students need to see themselves reflected in their mentors.
- Partnership institutions: local theatres, music conservatories, FabLabs, science museums, universities, tech companies, environmental NGOs, and cultural heritage organisations are all potential mentor sources.

Step 2: Brief your mentors before the programme begins

Mentors are not trained educators. A 2-hour orientation session (in person or online) is essential before they meet students. The briefing should cover:

1. The STEAM Innovation approach and the four-phase model (Feel, Imagine, Create, Share).
2. How to give effective feedback to young people: use 'I notice / I wonder / What if?' rather than 'You should...'
3. The specific STEAM product the student group is developing and its current stage.
4. The festival evaluation rubric criteria (see Section 4), so mentor feedback aligns with assessment.
5. Safeguarding and child protection requirements: sessions with students must include the school trainer/teacher; no one-to-one contact outside sessions.

Step 3: Structure the five-Month programme

Use the following session rhythm as a guide. Adapt timing to national school calendars and partner availability.

M1	Kick-off workshop	Mentor introductions; students present their STEAM product concept; mentor gives first impressions feedback; establish working relationship and communication channel.	Trainer facilitates; mentor observes and responds
M2	Skill-building workshop	Mentor leads a 90-min session on a relevant professional skill: pitching an idea, designing for an audience, the entrepreneurial canvas, or a technical skill relevant to the module.	Mentor leads; trainer supports
M3	Project review (Cycle 1)	Students present their revised first draft/prototype. Mentor gives structured feedback using 'I notice / I wonder / What if?' Trainer documents feedback.	Trainer facilitates; mentor gives feedback
M4	Skill-building workshop	Mentor introduces industry concepts: market research, branding, IP basics, or sustainability in creative practice.	Mentor leads; trainer supports
M5	Project review (Cycle 2)	Students present a substantially revised version. Mentor gives feedback against the festival evaluation rubric criteria.	Trainer facilitates; mentor evaluates

M6	Festival preparation workshop	Students rehearse their 3–5 minute festival pitch. Trainer and mentor give feedback on clarity, confidence, and scientific/artistic quality.	Trainer and mentor co-facilitate
M7	Local STEAM Festival	Students present their products publicly. Mentor serves on the evaluation committee where possible.	Trainer coordinates; mentor evaluates

Step 4: Guide student product development

The mentorship programme should support students through the following product development pathway. Make this pathway visible to students from the start:

1. Ideation: using Design Thinking brainstorming, generate at minimum 5–10 ideas before selecting one. Premature convergence on the first idea is the most common failure mode.
2. Scoping: complete a one-page product concept: What is it? Who is it for? What scientific concept does it embody? What artistic form does it take? What cultural heritage or environmental theme does it engage in?
3. First Prototype / First Draft: a version sufficient for a mentor to give meaningful feedback. For Theatre, a first script read-through. For Music, a rough recorded composition. For Making, a cardboard mock-up or digital model.
4. Mentor Review (Cycle 1): 30-minute structured session using 'I notice / I wonder / What if?'. Trainer facilitates and documents.
5. Revision: students revise based on mentor feedback. At least two revision cycles before the festival.
6. Mentor Review (Cycle 2): more detailed feedback against the festival evaluation rubric criteria.
7. Festival Preparation: finalise the product and rehearse the 3–5 minute festival presentation.

Step 5: Document every session

Documentation from the mentorship programme feeds directly into D3.3 (Implementation Activities Report) and D5.3 (Impact Assessment). After every session, complete:

- Trainer notes: what happened, what stage the student product is at, any concerns about group dynamics or progress.
- Mentor feedback form: brief written feedback from the mentor after each review session.
- Student reflection: a short 3-2-1 exit slip (3 things you noticed today, 2 things you will change, 1 question you have for next time).
- Photographs: of student work, mentor sessions, and key moments in the production process.

3.4 The Mentor briefing: What mentors need to know

For STEAM Innovation Mentors: A Quick Reference

What students have already done

Students have completed one or more of the three training modules (Theatre, Music, or Making & Tinkering) and have developed a first draft of a STEAM product. Your role is to help them develop and refine that product, not to redirect it.

How to give feedback that develops rather than directs

Use the 'I notice / I wonder / What if?' protocol: describe what you observe specifically; share a genuine question the work raises for you; offer one possibility for consideration. Avoid 'You should...', try 'One thing worth exploring might be...'

The entrepreneurial dimension

As the programme progresses, introduce students to real-world questions: Who would want this product? How could it reach them? What would it cost to produce? What makes it unique? These conversations prepare students for their festival pitch.

What a successful mentorship session looks like

Students leave the session with more questions than they arrived with, and with at least one concrete next step they have chosen themselves. If students leave with a list of things, you told them to do, the session could have been more powerful.

Safeguarding

All sessions involving students should be conducted with the trainer/teacher present. Do not arrange one-to-one contact with students outside of programme sessions. If you have any welfare concerns, speak to the trainer immediately.

3.5 Project development criteria and guidance for Mentors

The following criteria are designed to guide mentors in supporting student teams throughout the project development process. Rather than functioning as a competitive evaluation instrument, this framework serves as a practical reference that mentors can use during mentoring sessions to help teams understand what a strong, well-rounded STEAM project looks like, and to orient their work toward the standards that will be applied during the national festival selection process.

Mentors are encouraged to introduce these criteria early in the mentorship programme and to return to them regularly as student projects develop, so that teams can use them as a self-assessment and improvement tool rather than encountering them only at the point of final presentation. The criteria reflect the core values of the STEAM Innovation project: interdisciplinarity, creativity, scientific rigour, community engagement, collaboration, inclusion, sustainability, and innovation.

How to use this framework as a mentor

- Introduce the criteria at the first mentoring session. Walk through each criterion with the student team and ask them to self-assess their initial concept idea against each one.
- Return to the criteria at each subsequent review session. Ask teams to identify which criteria they have strengthened since the last session and which still need development.
- Use the 1–5 scale as a conversation tool, not a grade. The purpose is to help students understand the direction of improvement, not to produce a score.
- Pay particular attention to the module-specific criterion relevant to your module (Theatre, Music, or Making & Tinkering), as this is where students often need the most guidance.
- Ensure every team completes Festival-Ready Materials before the national festival date. This is the criterion most often underprepared.

Scoring guidance

Each project is evaluated on a scale from 1 to 5 across all criteria. For a project to score 4 or 5, it must also fully meet the requirements described at level 3 and 4 respectively, higher

scores are cumulative, not substitutive. The rubric applies equally to theatrical performances, musical compositions, and makerspace artefacts. All projects are assessed against the nine core criteria plus the one module-specific criterion relevant to their discipline.

Rubric criteria table

Criterion	Description	1	2	3	4	5
Scientific Accuracy & Technical Quality	Scientific accuracy and adequate use of technology, tools and/or techniques.	The project demonstrates scientific inaccuracy and/or poor use of technology, tools and techniques.	The project is based on adequate scientific arguments, but lacks adequate technology, tools and/or techniques.	The project is based on solid scientific arguments, demonstrating an evidence-based approach. Selected tools, technology and techniques are adequate to explore the theme.	The project demonstrates a solid understanding of the scientific arguments and of the technologies used.	The project demonstrates scientific and technological maturity. Students can confidently explain and argue about the scientific concepts and technical aspects.
Interdisciplinary and STEAM Integration	Interdisciplinarity and an adequate combination of STEAM fields (Science, Technology, Engineering,	The project explores only one STEAM area.	The project explores more than one STEAM area, but the connection between them is unclear.	The project explores more than one STEAM area and demonstrates a clear connection between them.	The project explores all STEAM areas; however, it lacks a solid explanation of such connections.	The project demonstrates a full STEAM approach. Students can confidently explain how the areas connect to each

	Arts, Mathematics).					other and to their project.
Originality and Creativity	Originality, innovative ideas and creative thinking.	The project seems to fully replicate already existing ideas.	The project replicates already existing ideas, but adds a creative element.	The project uses existing ideas and combines them in a creative and innovative way.	The project is mostly based on creative and original ideas.	The project is highly original, being fully based on innovative and creative ideas.
Relevance of the Chosen Theme	Addressing real needs, topics or problems.	The project does not show a connection with any real-life topic or problem OR does not propose solutions.	The project shows an unclear connection to a real-life topic or problem, even if it presents solutions.	The project relates to a real-life topic or problem, but the proposed solution lacks a clear connection.	The project relates to a real-life situation and presents a clear, coherent solution.	The project is highly relevant for a real-life topic or problem, presenting an adequate and purposeful solution.
Teamwork & Collaboration	Working as a team, Collaboration, communication	Teamwork is not visible or unclear. The project seems	The members demonstrate teamwork, but the	The members demonstrate a clear	The members seem to act as a team, demonstrating smooth, supportive,	The team works effectively, demonstrates initiative, respect,

	and shared responsibility.	to be fully led by one person.	distribution of roles seems unbalanced.	and even role distribution.	and well-coordinated work.	and shared leadership.
Environmental Awareness and Sustainability	Environmental and social awareness, and responsible use of resources.	The project demonstrates a negative impact on the environment and/or on humans or other beings by promoting damaging actions or by using wasteful and/ or polluting materials.	The project is not directly damaging to the environment, humans or other beings; however, it does not clearly demonstrate care for environmental impact and sustainability issues.	The project demonstrates environmental and social awareness, but lacks responsible resource use.	The project demonstrates a careful selection of resources and techniques, demonstrating environmental and social awareness.	The project demonstrates environmental and social awareness and careful decision-making when selecting resources. The project is considered zero-waste.
Communication & Presentation	Clear, engaging and effective presentation and communication.	The presentation of the project is incomplete or does not demonstrate a clear	The presentation of the project is complete, but poorly structured or poorly explained.	The presentation of the project is effective, with clear explanations and structure.	The presentation of the project is effective, well-structured and well-explained. The project demonstrates	The presentation of the project is engaging, clear and impactful. The project is visually appealing.

		understanding of the theme.			clear consideration of visual elements.	
Openness & Licensing	Open education values and the ability to share and replicate the process and results.	The project is not open to be shared or replicated.	The project is open to be shared; however lacks resources to facilitate replication (documentation, links, guides, etc.)	The project is open and includes documentation, but it is unclear how to fully replicate it.	The project is shareable, open and easy to replicate.	The project is purposefully developed in an open, replicable way. Documentation is ready and open for use. The project includes an open license
Festival-Ready Materials (Videos, Trailers, Presentations)	Being ready to participate in a festival, preparing materials for hands-on experiments, physical	The project lacks materials to be demonstrated.	The project has visual aids such as posters or trailers but lacks a functioning physical prototype to be demonstrated in the festival.	The project has a functional prototype/experiment to be demonstrated at the festival.	The project has a functional and interactive prototype/experiment .	The project has a complete set of festival-ready materials, including a functional and interactive physical/digital prototype/experiment

	artefacts and visual aids (posters, trailers, etc.).					and other supporting materials and visual aids.
Module-Specific Criteria: “Maker & Tinkering Process with Design Thinking”	Following a maker approach with the Design Thinking process. Using a diversity of technologies and techniques, combining them to create a functional physical/digital artefact that serves the goal of the project	The project shows little or no evidence of tinkering/maker or the Design Thinking approach.	The project shows evidence of following a tinkering/maker approach or the Design Thinking process, but not both.	The project shows an evident tinkering/maker approach and has followed some steps of the Design Thinking process, or vice versa.	The project demonstrates a clear tinkering/maker approach, following all steps of the Design Thinking process.	The project shows a clear blend of the tinkering/maker approach with Design Thinking, with a rich process of experimentation, multiple prototypes and learning from mistakes.

Module-Specific Criteria “Theatre”	In the context of the module, students from all grades (primary & secondary schools) are expected to dramatize scientific notions and knowledge drawn from their school curriculum. The final output should be a performance of up to 20 minutes. In this module in order to evaluate the performance as	The performance shows significant weaknesses in multiple areas, with limited coherence and minimal connection to scientific concepts.	Basic elements are present, but their development is limited and the overall presentation lacks completeness and coherence.	The performance meets the basic criteria adequately, with some positive elements, but without notable originality or strong impact.	The performance is well-developed, creative, and coherent, with good integration of scientific concepts and a positive impact on the audience.	The performance stands out for its high quality, originality, and strong coherence across all elements, with outstanding integration of scientific concepts and a particularly strong audience impact.
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	a whole, it should be taken into account: the quality and originality of the script, the direction and stage performance, the creative use of music, sets, choreography and costumes, the integration of scientific concepts, and the overall execution and impact on the audience.					
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Module-Specific Criteria “Music”	Using musical elements (pitch, rhythm, timbre, dynamics) and sound technologies to represent scientific ideas, data or phenomena.	The project shows little or no use of music/sound to explore the scientific theme. Sound elements are absent or unrelated to learning objectives.	The project includes some music or sound, but the connection to science is unclear. Use of tools or instruments is mostly imitative.	The project shows a clear attempt to link music with scientific concepts (e.g. waves, data, ecosystems). Students use digital tools or handmade instruments to create original sounds.	The project demonstrates a coherent integration of music and science. Musical choices intentionally represent data or phenomena, and students can explain their decisions.	The project demonstrates advanced and meaningful fusion of music, science and technology. Sound is clearly used as a living language with clear map experimentation and reflection.
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3.6 Examples of Mentorship implementation, National contexts

The following sections document how the mentorship programme was implemented in each partner country during WP3. Each partner has selected one example from their national implementation to illustrate how the mentorship process supported student teams in developing their projects from initial concept through to festival-ready presentation. The examples are presented as practical case studies for other trainers and mentors, showing how the guidance framework above was applied in real educational contexts.

Greece, Science View

Case Study from Greece: Mentoring the “Mission to Mars” Student Project

In Greece, the mentorship programme supported school teams in moving from an initial STEAM idea to a complete theatrical performance ready for presentation at the Learning Science Through Theater Festival. One representative example was the primary school project “Mission to Mars”, developed by 5th grade students, aged around 11. The project involved a large preparation process with 142 students participating in preparatory activities, while around 20 students took part in the live stage performance, supported by their teachers and the wider school team. The initial concept was connected to the students’ interdisciplinary work on a journey to Mars, which provided a rich context for combining science, storytelling, music, digital creation, and theatre. According to the school’s planning, students worked collaboratively in small groups to create science-fiction stories structured around key stages of a Mars mission: preparation and astronaut training, launch and travel through space, life in the International Space Station, landing, and the creation of a shelter on Mars. Alongside script development, students engaged in science activities and experiments related to gravity, Martian soil simulation, atmospheric conditions, materials, floating in space, and astronaut preparation, using these scientific experiences as inspiration for their narratives.

The mentorship process helped the team transform this broad interdisciplinary theme into a coherent theatrical STEAM performance. Guidance focused on strengthening the connection between the scientific content and the dramatic structure, supporting teachers and students in turning research and classroom experiments into characters, scenes, dialogue, soundscapes, and stage action. Particular emphasis was placed on student agency: students wrote stories, created digital books, developed visual material, composed sound motifs and musical ideas, and contributed to the final performance through theatre, music, projections, and backstage roles. The project followed a process aligned with the stages Feel – Imagine – Create – Share,

encouraging students first to explore the challenges of space travel, then to imagine creative solutions and scenarios, create theatrical and digital material, and finally share their work with the school community and the wider LSTT audience. The final performance presented a mission to Mars as a collective journey of exploration, highlighting teamwork, scientific knowledge, calmness under pressure, and the idea that scientific progress is achieved through cooperation rather than individual achievement. In this way, the Greek mentorship framework supported the school team not only in preparing a festival-ready presentation, but also in implementing a complete learning journey where science, creativity, music, digital media, and theatrical play were meaningfully integrated. Full details of the project and the wider Greek implementation are included in the Report from Greece.



Figure 8: *Photos from rehearsals of the team (photos by Science View)*

Cyprus, INQUIRY FUSE

In Cyprus, the mentorship programme took shape as a sustained, week-by-week accompaniment of two school teams, one primary, one secondary, across five months of creative and scientific development, from the first workshop sessions in January 2026 through to the public showcase events in May. The example presented here comes from the primary school strand of the implementation: the project "Aligned", created by four Year 5 students at Pascal International School in Nicosia, a private international school with a culturally and linguistically diverse student body. The team called themselves Lumen & Shadow, and their chosen subject was the solar eclipse, a phenomenon they approached not as a topic to explain, but as an experience to recreate.

What made this project distinctive from the outset was the nature of the question the students brought to their first mentoring session. They were not asking how an eclipse works, they had already begun to understand that. They were asking something harder: how do you make someone else feel it? That question became the engine of the entire mentorship process. Rather than guiding students toward a correct answer, mentors from Inquiry Fuse held the question open and helped the team explore it from multiple directions, scientific, musical, and performative, across a series of sessions that gradually moved from open inquiry toward a concrete artistic production.

In the early mentoring sessions, the focus was on scientific grounding. Students studied the mechanics of eclipse formation in depth, the geometry of alignment between Earth, Moon, and Sun, the progression of the shadow, the physical qualities of light at each stage of totality, so that when they later made compositional decisions, those decisions would be anchored in real knowledge rather than atmospheric impression. Mentors worked alongside the class teacher and the school's music teacher to ensure that the scientific and artistic dimensions of the project were developed in dialogue with each other rather than in separate tracks. In the middle sessions, the focus shifted to the songwriting process. Students worked on how musical elements, the arc of a melody, the weight of a chord, the timing of silence, could carry scientific meaning, so that the gradual dimming before totality and the suspended stillness of the eclipse itself became audible experiences rather than illustrated facts. In the later sessions, the focus moved to performance: how to stand on a stage with four people and a song, and make a room feel the disappearance of the sun.

Throughout the process, mentors were deliberate about not leading. The song "Aligned", its lyrics, its melody, its structure, its emotional decisions, was made entirely by the students. The mentorship provided the conditions in which that making could happen: the scientific knowledge, the artistic vocabulary, the feedback at each iteration, and the encouragement to trust that what they were creating was worth sharing publicly. The project moved through the stages Feel → Imagine → Create → Share in a way that felt organic rather than prescribed: the students felt the eclipse through scientific investigation and imaginative engagement, imagined a musical form that could hold it, created the song and the performance through rehearsal and refinement, and shared it as the opening act of the showcase event "Show Must STEAM On" at Pascal International School in Nicosia. The performance was recognised by the evaluation committee for the precision with which its musical structure mirrored the scientific phenomenon, and for the uncommon stage confidence and emotional clarity of students who had just turned eleven. The project was selected as one of the three Cyprus projects to represent the country at the transnational STEAM Innovation festival in Matera, Italy, in September 2026.

The Cyprus mentorship experience with Lumen & Shadow illustrates something that is easy to state but harder to achieve in practice: that the role of the mentor is not to make a project better, but to make the students capable of making it better themselves. The five months of weekly support, school visits, and one-to-one sessions that characterised the Cyprus implementation were not about quality control, they were about building the scientific understanding, the artistic confidence, and the creative trust that allowed four primary school students to walk onto a stage with an original song about the physics of light and mean every

word of it. Full details of the project and the wider Cyprus implementation are included in the Report from Cyprus.



Figure 9: Photos from the mentorship programme in Cyprus (Photos by Inquiry Fuse).

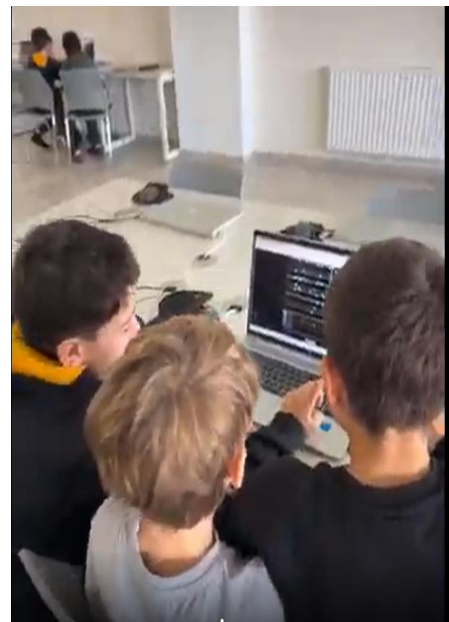


Figure 10: Photos from the implementation phase and the mentoring with teachers and students, in Cyprus (Photos by Inquiry Fuse).

Italy, Materahub

In Italy, the mentorship programme coordinated by Materahub supported school teams in moving from an initial STEAM idea to a complete audiovisual and musical performance ready for presentation within the STEAM Innovation activities. One representative example was the student project “Il Respiro della Terra – The Breath of the Earth”, developed by students from third year of High school (15-16 years old). The project involved students from different artistic and audiovisual study pathways who collaborated through interdisciplinary workshops focused on climate change, environmental sustainability, and the relationship between humanity and nature. The initial concept emerged from collective discussions and classroom reflections on the environmental crisis and the progressive deterioration of ecosystems caused by pollution, overconsumption, and climate imbalance. Students explored these themes not only through scientific information and research, but also through emotional interpretation, symbolic narration, music, and audiovisual experimentation.

The mentorship process helped the team transform this broad environmental theme into a coherent immersive STEAM production. Guidance focused on strengthening the connection between scientific reflection and artistic creation, supporting teachers and students in turning environmental concerns into soundscapes, visual metaphors, rhythms, digital projections, symbolic imagery, and audiovisual sequences. Particular emphasis was placed on student agency: students contributed to soundtrack selection, sound experimentation, visual composition, video editing, digital storytelling, and the creation of the final immersive experience. The project followed a process aligned with the stages Feel – Imagine – Create – Share, encouraging students first to explore the emotional and social consequences of environmental degradation, then to imagine creative ways to represent the “breath of the Earth” through artistic language, create audiovisual and musical material collaboratively, and finally share their work with the school community and the wider STEAM Innovation audience. The final performance presented the Earth as a living organism whose breath becomes increasingly fragile under environmental pressure, highlighting the urgency of sustainability, collective responsibility, and active citizenship. In this way, the Italian mentorship framework supported the students not only in producing an artistic audiovisual outcome, but also in implementing a complete learning journey where science, creativity, music, digital media, environmental education, and emotional engagement were meaningfully integrated. Full details of the project and the wider Italian implementation are included in the Report from Italy.



Figure 11: *Photos from the mentorship programme in Italy (Photos by MateraHub)*

Portugal, NUCLIO

In Portugal, the mentorship sessions supported teachers and students during the implementation of the “learning STEAM through Making&Tinkering” module and in the development of their own STEAM projects. Complementing the professional development programme delivered by NUCLIO, 12 mentorship sessions were carried out in diverse formats:

- School visits
- Online meetings
- Personalized training sessions
- Regular feedback and support

Having access to the evaluation rubrics, teachers and students set out to develop projects to showcase in the National STEAM Innovation festival and, if selected, in the international one. Considering the diverse nature of such projects, mentorship sessions were tailored to their different needs.

One example was the primary school project "Menos Ruído, Mais Sabor" (Less Noise, More Flavour), developed by students from the 2nd, 3rd and 4th years at EB António Rebelo de Andrade, led by teachers Inês Mateus, Joana Soares, and Mafalda Marques. 69 students took part, working across six curricular subjects: Portuguese, Mathematics, Environmental Studies, Arts Education, Citizenship and Development, and ICT.

The project started with a problem identified by students: the school canteen was too noisy. Following the Feel, Imagine, Create and Share Design Thinking phases, students researched the problem, proposed solutions, built a working prototype and shared it with the school community. The chosen solution was a micro:bit connected to an LED strip that shifted gradually from green to yellow to red as noise levels rose, giving students a visual signal to regulate themselves. One student suggested calling it "a noise traffic light!", and when the light first turned red during a canteen test, students started telling each other "já está vermelho, falem mais baixo" (it's red already, speak lower).

Mentorship combined virtual support to teachers and in-person sessions with students. Teachers received support on micro:bit programming, LED strip control.

With students, mentors ran three sessions of 90 minutes each, one per year group. In the first session, 4th year students learned to use the micro:bit sound sensor, write if-then-else logic conditions, work with variables, and control LED colours according to sound volume. In the second session, two 4th year students joined the mentor to support the 2nd year group,

applying the same programming principles. In the third session, four 4th year students took the lead with the 1st year group, guiding younger students, who are still learning to read, through programming the micro:bit to light the LED strip according to sound volume.

The role of mentors shifted across the three sessions. It started as instructive and became progressively supportive, as students gained experience and confidence and no longer needed the mentor or the teacher to put their ideas into practice.



Figure 12: *Photos from the mentorship programme in Portugal (Photos by NUCLIO)*

4. Conclusions

This Handbook for STEAM Trainers (D4.1) brings together the pedagogical rationale, practical facilitation guidance, lesson plans, case studies, and mentorship tools that trainers across the STEAM Innovation Ecosystem project need to deliver, adapt, and sustain integrated STEAM learning experiences in their national contexts. Reading it alongside the Modular STEAM Educational Curriculum (D2.3) gives trainers a complete professional picture: D2.3 provides the learning content and student-facing activity sequences; D4.1 provides the understanding, the strategies, and the real implementation evidence that enable those activities to come to life in a classroom, a makerspace, a rehearsal room, or a school stage.

The implementation experiences documented across this handbook, from 27 school teams in 13 regions of Greece, to two schools in Nicosia and Paphos, to ten teams at Matera's Liceo Artistico C. Levi, to 56 teachers and more than 580 students across 11 schools in Portugal, collectively demonstrate something that the STEAM Innovation project set out to prove: that the integration of arts, science, technology, and mathematics is not a pedagogical compromise between rigour and creativity. When implemented with sustained support, genuine artistic ambition, and a clear scientific anchor, it is a deeper and more durable form of learning than either discipline achieves alone.

Several conclusions emerge consistently across all four partner countries and all three discipline modules.

First, the Feel phase is the most important and the most frequently underestimated. In every national context, the projects that produced the most original, scientifically grounded, and artistically mature outcomes were those in which students spent significant time genuinely identifying a problem, posing their own questions, and developing real ownership over the inquiry direction before any tool was introduced or any artistic form was chosen. Trainers who invested in this phase, even when it felt slow or uncertain, consistently reported stronger student engagement and higher quality final products.

Second, the trainer's role is fundamentally different from the teacher's role in conventional education. Every module in this handbook asks trainers to resist the instinct to explain, to direct, and to correct, and to replace it with the discipline of facilitating, questioning, and

trusting. This shift is difficult, particularly for educators with strong subject expertise, and it requires ongoing support. The mentorship model documented in Section 3 is not only a structure for supporting students; it is equally a model for supporting trainers through a professional development process that is genuinely challenging and genuinely rewarding.

Third, inclusion is a design requirement, not an aspiration. The most inclusive projects documented in this handbook, the Lumen & Shadow solar eclipse performance by Year 5 students in Nicosia, the Music Pythons' data sonification project at a school serving predominantly migrant students in Paphos, the noise traffic light prototype designed by primary students in Portugal ,were inclusive because they were designed from the outset to allow students to contribute according to their strengths, to value different forms of intelligence and expression equally, and to connect scientific learning to something the students genuinely cared about. Inclusion that is added after the design is made tends not to hold.

Fourth, public sharing transforms learning. Across every national context, the moment of public presentation, the festival performance, the showcase event, the school exhibition ,was consistently identified by teachers, mentors, and students as the most transformative moment of the entire process. The knowledge that real people would witness their work changed how students invested in it. Trainers should plan for this moment from the very beginning of the module, not as a destination but as a horizon that gives the entire journey its direction and its stakes.

Finally, and most fundamentally, the STEAM Innovation implementation across all four partner countries demonstrated that when young people are positioned as creators rather than recipients, when they are trusted with real questions, real tools, real audiences, and real time, they produce work of genuine scientific and artistic quality that surprises everyone, including themselves. This is what the handbook is for: not to provide a script, but to equip the trainer with enough understanding, enough practical guidance, and enough confidence to create the conditions in which that surprise becomes possible.