



**L~STEAM**

# Learning STEAM Through Performing Arts

## WP2: L-STEAM Competence-Based Framework

Outlining Key STEAM Competencies

Date: May 2025



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<b>Short Description</b>	The document describes the pedagogical framework of the L-STEAM project.		

# 1. Introduction

The Competence-Based Framework serves as a bridge between STEAM education and Performing Arts, emphasizing their integration to foster essential 21st-century skills<sup>1</sup>. By shifting the focus from traditional content-based learning to a competence-driven approach, this framework highlights how artistic expression enhances creativity, critical thinking, and interdisciplinary problem-solving. The STEAM IDEAS' Square (SIS) further reinforces this connection by providing a collaborative space where students engage in hands-on, artistic exploration of scientific and technological concepts.

## 1.1. Purpose of the Competence-Based Framework

The Competence-Based Framework of the L-STEAM project, serves as a guiding document to bridge the gap between STEAM (Science, Technology, Engineering, Arts, and Mathematics) education and the Performing Arts. As education evolves to meet the demands of a rapidly changing world, there is a growing recognition of the need for interdisciplinary approaches that foster creativity, critical thinking, and practical application of knowledge. By integrating Performing Arts within STEAM education, this framework highlights how artistic expression can enhance problem-solving, innovation, and collaboration, making learning more dynamic and impactful.

The purpose of this document is to provide educators, policymakers, and curriculum developers with a structured approach to embedding Performing Arts within STEAM learning environments. Through this integration, students are encouraged to explore scientific and technological concepts through theatrical performances, musical compositions, movement, and storytelling. These creative methodologies not only support deeper cognitive engagement but also develop essential competencies such as adaptability, resilience, and effective communication. By focusing on experiential learning, this framework aims to equip students with skills that are relevant across disciplines and applicable in real-world scenarios.

Moreover, this framework aligns with contemporary educational policies that emphasize competency-based learning. Rather than focusing solely on knowledge acquisition, the framework promotes a learner-centered approach where students demonstrate mastery of key competencies through artistic and interdisciplinary projects. This methodology encourages personalized learning paths, hands-on exploration, and a greater appreciation for the interconnectedness of STEAM disciplines. Ultimately, the Competence-Based Framework aims to establish a holistic model of education where Performing Arts serve as both a learning tool and an essential element of scientific and technical literacy.

## 1.2. The Need for STEAM Competences

The OECD's *Fostering Students' Creativity and Critical Thinking* report provides a framework to help teachers integrate these skills into the curriculum. However, many educators feel unprepared due to the lack of a shared professional understanding of how creativity and

<sup>1</sup> <https://unesdoc.unesco.org/ark:/48223/pf0000242996.locale=en>



critical thinking manifest in formal education. STEAM education addresses this gap but remains underutilized. Some fear that emphasizing creativity and critical thinking may detract from core subject knowledge, yet STEAM's interdisciplinary, hands-on methods reinforce both. Others worry about time constraints and disruptions to traditional structures, but STEAM inherently supports adaptable, inquiry-driven learning. According to the recently published **EC's Communication "A STEM Education Strategic Plan"**, a key barrier is the absence of clear models, making implementation difficult. Based on the recommendations of the Strategic Plan, embedding STEAM principles—problem-solving, experimentation, collaboration—into daily teaching can bridge this gap. Across Europe, STEAM integration varies due to differing policies, infrastructures, and teacher readiness. Many countries lack standardized approaches, with rigid subject structures limiting transdisciplinary learning. Gender disparities persist, especially in engineering and technology, requiring inclusive education strategies. Real-world applications are needed to boost student interest in STEAM fields.

**The Road-STEAMer project, involving L-STEAM consortium partners (EA, SV, UM), highlights systemic barriers and enablers for STEAM education in Europe**, has found that while STEAM is gaining recognition, integration remains fragmented, relying on individual teacher initiative rather than structured policies and professional development. Curricula advocate for interdisciplinary learning but are constrained by rigid subject divisions. Traditional assessments focus on content rather than STEAM competencies like problem-solving and collaboration, limiting students' ability to develop real-world skills. Teacher training is the most pressing need. Many educators lack experience in transdisciplinary, inquiry-based STEAM methods and need better access to quality teaching materials, best practices, and peer support. Without structured professional development, STEAM risks remaining in isolated pilot projects rather than becoming a systemic transformation. Road-STEAMer recommends targeted interventions, particularly structured teacher training pathways. **The L-STEAM project builds on these findings, providing scalable, modular training, open educational resources, and innovative assessment tools.** It also fosters a European knowledge-sharing network and contributes to policy discussions, ensuring STEAM education's long-term impact.

## 1.2.1. Needs for Teachers' Professional Development in STEAM

As Europe advances towards a knowledge-based and innovation-driven economy, the demand for STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has never been greater. STEAM learning fosters interdisciplinary problem-solving, creativity, and critical thinking—skills essential for preparing students to navigate an increasingly complex and technology-driven world. However, **to effectively integrate STEAM into classrooms, teachers require continuous professional development** that equips them with the necessary pedagogical strategies, subject expertise, and confidence to implement innovative teaching approaches. One of the main aims of the L-STEAM project through the Continues Development Courses (Summer Schools).

One of the most pressing needs is to **provide educators with structured training that moves beyond traditional disciplinary silos.** Many teachers feel unprepared to teach in interdisciplinary ways, as their own training has often been rooted in single-subject



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instruction. Professional development programs must therefore offer hands-on, experiential learning opportunities where educators can explore project-based and inquiry-based methodologies that reflect the real-world interconnectedness of STEAM disciplines. Training initiatives should also focus on equipping teachers with the skills to facilitate student-centered learning, encouraging collaboration, experimentation, and problem-solving rather than rote memorization of content.

**Collaboration among educators, researchers, and industry professionals** is another critical aspect of effective STEAM professional development. Teachers often work in isolation, without the opportunity to exchange ideas or co-develop transdisciplinary curricula. Establishing **professional learning communities, mentorship programs, and partnerships with universities, research centers, and businesses** can help educators stay updated on advancements in STEAM fields while also providing them with real-world applications to bring into their classrooms. Such collaborations can enrich teaching practices and create more dynamic learning environments that reflect the latest scientific and technological innovations. This will be the contribution of the L-STEAM project by providing the framework and the guidance on how to operate the STEAM IDEAS' Square.

Finally, for professional development initiatives to be successful, they must be **embedded within national and regional education policies**. While many European countries have recognized the importance of STEAM education (as described above), there remains a need for coherent, long-term strategies that ensure teachers receive sustained support rather than one-off training sessions. Policymakers should prioritize funding for STEAM-focused teacher training, provide time and resources for professional learning within school schedules, and establish clear guidelines for integrating STEAM approaches into national curricula. The proposed L-STEAM Competence based Framework is contributing to the above by proposing specific strategies and activities not only for each one of the participating countries but also for specific school typologies that will be able to involve their teachers and students independently of the level of STEAM integration they are.

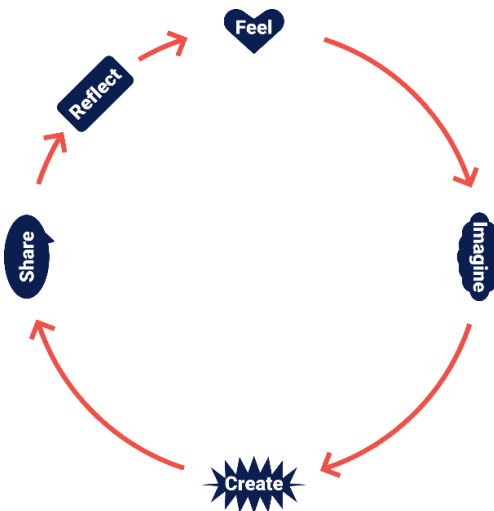
**Investing in teachers' professional development in STEAM is an investment in the future of education and workforce development in Europe.** By equipping educators with the skills, confidence, and resources to implement interdisciplinary and technology-enhanced learning, Europe can nurture a generation of students who are not only proficient in STEAM subjects but also prepared to think critically, innovate, and tackle the challenges of the 21st century.

### 1.3. Relationship with the STEAM IDEAS' Square Environment

The STEAM IDEAS' Square (SIS) is a dynamic environment where science, art, and society intersect to foster creativity, innovation, and interdisciplinary collaboration. Designed as a space that encourages idea generation and experimentation, SIS provides students and educators with opportunities to engage in creative problem-solving through performing arts. By integrating artistic expression into STEAM education, SIS creates an immersive learning environment where students FEEL societal needs, IMAGINE novel solutions, CREATE within the school, and SHARE their outcomes with the broader community.



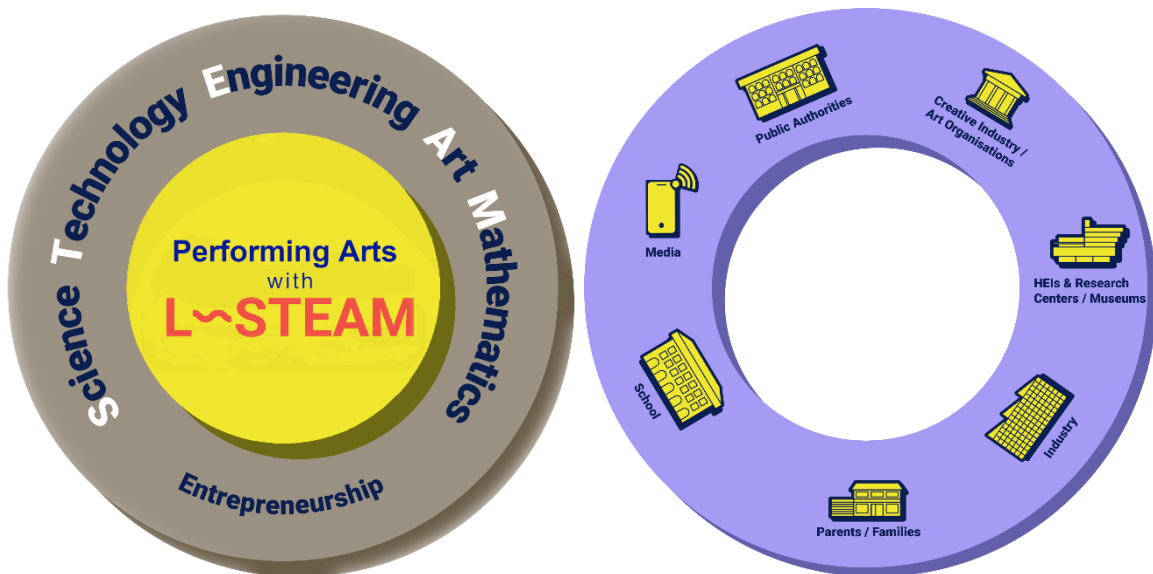
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**Figure 1:** *Feel, Imagine, Create, Share. The Design-Thinking collaborative scheme in education*

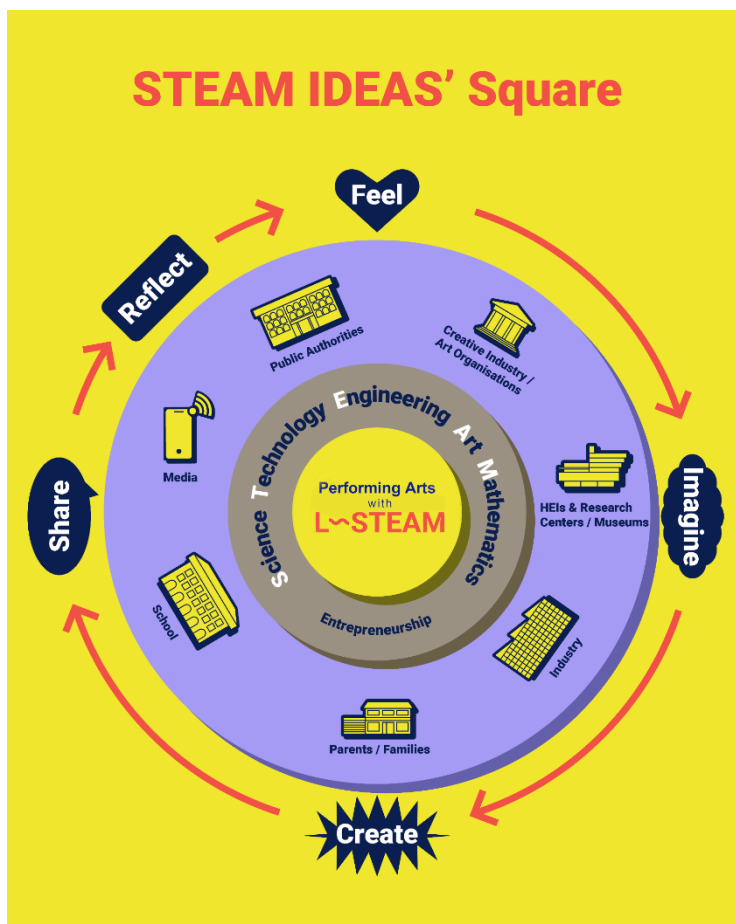
This circular collaborative setting allows learners to explore scientific and technological concepts through storytelling, movement, music, and dramatic performances, making abstract ideas more tangible and engaging.

SIS fosters a strong connection between education and the community by encouraging students to showcase their STEAM-based artistic projects to a wider audience. Public performances, exhibitions, and digital media presentations create opportunities for meaningful dialogue between students, educators, professionals, and the public.



**Figure 2:** *left: STEAM and Entrepreneurship are part of the project's steering process. right: The societal stakeholders are part of the STEAM IDEAS' SQUARE role in the project's pedagogical scheme*

This engagement reinforces the societal impact of STEAM learning and highlights the importance of artistic communication in making scientific concepts accessible and compelling. By integrating performing arts into STEAM education through SIS, the Competence-Based Framework not only nurtures essential 21st-century skills but also transforms learning into an expressive, collaborative, and impactful experience.



**Figure 3:** The STEAM IDEAS's SQUARE concept within L-STEAM project

Within the competence-based framework, SIS serves as a bridge between structured academic learning and experiential, hands-on discovery. It shifts the focus from rote memorisation to the development of key competencies such as critical thinking, adaptability, and interdisciplinary knowledge. By integrating performing arts into STEAM education, SIS encourages students to think beyond traditional disciplinary boundaries and engage with science and technology through creative mediums. For example, theatrical improvisation can be used to simulate real-world scientific challenges, while musical compositions can represent mathematical and physical principles, reinforcing both artistic and analytical skills.

Performing arts act as a catalyst for innovation within SIS by enabling students to prototype and test ideas through artistic performances, digital storytelling, and interactive installations. This iterative design process, often found in engineering and scientific research, is also



inherent in the creative arts. By merging these methodologies, SIS supports a learning approach where students experiment, refine, and develop solutions in a way that mirrors real-world problem-solving. Through role-play and dramatic reenactments, students can explore ethical dilemmas in technology, visualize historical scientific breakthroughs, and engage in collaborative projects that blend artistic creativity with technical precision.

## 2. Core STEAM Competencies Through Performing Arts

The L-STEAM approach aligns with competency-based learning, ensuring that students develop adaptability, communication, and resilience alongside scientific and artistic knowledge. Through theatre, music, movement, and storytelling, students engage in hands-on exploration that enhances both technical and interpersonal skills.

The competencies explored in the following sections highlight how Performing Arts serve as both a method and an outcome of STEAM education. By encouraging critical thinking, interdisciplinary connections, inquiry-driven projects, and creative expression, this framework transforms learning into an interactive and meaningful experience by equipping students with skills that extend beyond the classroom.

### 2.1. Creative and Critical Thinking in Performing Arts

- Encouraging problem-solving through improvisation, role-playing, and dramatic storytelling.
- Using design thinking in theatre productions, where students iteratively develop scripts, characters, and stage concepts.
- Applying science notions thinking in staging a production—combining lighting, acoustics, set design, and narrative structure into a cohesive whole.

The STEAM IDEAS' Square encourages students to explore societal needs through the lens of imagination and performance, making it an ideal environment for nurturing creative and critical thinking. Within this space, students use improvisation, theatrical scenarios, and musical interpretation to examine complex issues and generate original solutions. These performative processes engage learners in reflective practice, encouraging them to evaluate ideas, adapt perspectives, and innovate through artistic experimentation. Performing Arts become a vehicle for developing divergent thinking and the capacity to analyze challenges from multiple viewpoints.



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## 2.2. Interdisciplinary Knowledge Through the Arts

- Connecting science, technology, engineering, and mathematics with theatre and music to create integrated learning experiences.
- Using movement and rhythm to explore mathematical patterns, physics of sound, or biological motion.
- Fostering innovation by integrating performing arts with technology such as interactive digital performances.

The collaborative and integrative nature of the STEAM IDEAS' Square promotes the blending of scientific and artistic disciplines. By staging performances or creating soundscapes that explore scientific principles, students naturally connect knowledge from various fields. Using movement and rhythm to model mathematical patterns or biological processes allows learners to physically engage with abstract ideas. Additionally, performing arts projects that incorporate digital tools and emerging technologies provide opportunities for students to experience innovation at the intersection of disciplines. SIS fosters an environment where the boundaries between subjects are blurred, and learning becomes an interconnected, meaningful experience. The use of digital tools such as eShadow, can enable students to perform collaborative plays using tools that enhance their creativity, while studying other forms of arts, such as puppet and shadow theater.

## 2.3. Cooperation and Communication in Performing Arts

- Enhancing teamwork through group performances, musical ensembles, and collaborative scriptwriting.
- Developing effective communication by using dramatic expression, voice modulation, and body language.
- Strengthening intercultural competence by exploring global theatrical traditions, folk music, and multilingual storytelling.

Performing Arts inherently rely on collective effort—group performances, ensemble music, and collaborative scriptwriting cultivate strong teamwork skills. Through rehearsals and performances, students learn to communicate ideas clearly, listen actively, and adapt to group dynamics. The expressive tools of theatre—voice, gesture, and movement—enhance verbal and non-verbal communication. Moreover, by engaging with multicultural and multilingual content, students build intercultural awareness and the ability to collaborate with diverse peers, mirroring the kind of inclusive cooperation needed in real-world innovation environments.

## 2.4. Technological Literacy in the Performing Arts

- Integrating digital tools such as projection mapping, virtual sets, and sound engineering in theatre productions.
- Exploring the role of Artificial Intelligence in scriptwriting, dance choreography, and interactive stage performances.
- Teaching responsible technology use through digital storytelling, online performances.

Performing Arts integrate digital creativity into artistic exploration, allowing students to engage with emerging technologies in meaningful ways. In SIS, learners experiment with projection mapping, sound engineering, and virtual stage environments to enrich their performances. The use of AI or interactive media in theatre offers students hands-on experience with cutting-edge tools. By creating digital stories or performing in virtual spaces, students develop awareness of digital ethics, cybersecurity, and the responsible use of technology. Additionally, and equally important, students will understand how to use AI tools ethically, to enhance their stories without sacrificing their own creativity. This blend of performance and technology cultivates fluency in tools that are essential for contemporary expression and innovation.

## 2.5. Research and Exploration Skills Through the Arts

- Encouraging inquiry-based learning by having students research historical theatre, music, and cultural influences.
- Using dramaturgy and music analysis to critically examine narratives, social themes, and artistic expressions.
- Applying scientific literacy through movement analysis, voice modulation physics, or musical acoustics experiments.

The process of preparing a performance within the SIS setting involves substantial inquiry, reflection, and iteration—skills central to research and exploration. Students investigate historical, cultural, and scientific contexts for their artistic projects, whether scripting a play about climate change or composing a piece inspired by mathematical patterns. As they experiment and refine their work, they learn to ask meaningful questions, gather and interpret information, and apply their findings creatively. The open-ended, project-based format of the SIS nurtures curiosity and positions learners as active investigators.

## 2.6. Artistic and Creative Expression in STEAM

- Enhancing creativity through theatre improvisation, musical composition, and expressive movement.
- Using performing arts as a medium to represent scientific and mathematical concepts (e.g., using dance to demonstrate molecular movement).
- Encouraging storytelling as a method to convey scientific discoveries and social challenges.

Students are encouraged to communicate ideas through performance, music, gesture, and voice, developing their ability to express complex concepts in imaginative ways. Whether illustrating a physics principle through movement or using sound design to represent a scientific process, the arts allow for nuanced, affective engagement with content. This expressive dimension of learning supports the pedagogical framework's goal of cultivating both intellectual and emotional intelligence in students.

## 2.7. Adaptability and Resilience Through Performance

- Building flexibility by adapting to different roles, narratives, and real-time performance challenges.
- Teaching students to embrace failure as part of the creative process, such as refining a performance through feedback.
- Promoting a growth mindset by integrating reflective practice and continuous learning in artistic exploration.

A STEAM-competence pedagogical-setting naturally challenges students to embrace uncertainty, take risks, and respond flexibly to feedback—all of which build adaptability and resilience. Rehearsing, revising, and performing require learners to work through setbacks and continuously improve their work. The iterative nature of artistic production mirrors scientific inquiry and engineering design, reinforcing a mindset of persistence and growth. By participating in collaborative, evolving projects, students learn to navigate change with confidence and creativity.

## 3. Applying the Competence-Based Framework in Education

### 3.1. Implementation Strategies for Schools and Educators

As STEAM education evolves toward a more competence-based and inclusive model, a central challenge lies in translating abstract frameworks into concrete and context-aware practices within schools. Educators and school leaders often operate within highly diverse environments—shaped by differences in institutional structure, available resources, pedagogical cultures, and community dynamics. For this reason, the application of a common competence-based framework must be adaptable, responsive, and grounded in the everyday realities of teaching and learning.

This part of the report addresses the need for implementation strategies that reflect this diversity. It begins by examining how schools can engage with the framework based on their specific typologies, acknowledging that no single strategy fits all. It then broadens the perspective to explore civic engagement strategies, focusing on how collaboration with social stakeholders—such as parents, cultural organizations, and local authorities—can reinforce the effectiveness and sustainability of competence-based STEAM initiatives. Together, these strategies provide a foundation for meaningful, systemic change, fostering environments where educators are supported and learners are empowered.

#### 3.1.1. School engagement strategies connected to school typologies

Each school is following different approaches according to the county's educational system. The L-STEAM will develop specific strategies according to school typologies that will respond to the level of STEAM characteristics that are integrated in the school unit as well as in which level they are implemented. The STEAM characteristics should follow the STEAM Competencies Through Performing Arts that were defined in chapter 2.

The L-STEAM project will follow the already existing and tested typologies from the NEXT STEP project corresponding to the level of STEAM integration in school units. These are presented in Table 1.

**Table 1: The School typologies**

<b>STARTER</b>	<b>ENABLED</b>	<b>ADVANCED</b>	<b>MASTER</b>
<i>Schools that are planning to incorporate STEAM educational activities in their classrooms.</i>	<i>Schools that have implemented at least one STEAM education activity by means of collaboration between teachers of various STEAM disciplines.</i>	<i>Schools that have achieved a high degree of STEAM education, by actively promoting collaboration between teachers of various STEAM disciplines in e.g., a project-based learning approach. ICT tools are integrated in their practices. Cooperation with community stakeholders and other external partners on specific STEAM activities/projects has been established</i>	<i>Schools that have STEAM learning as a common practice among their teachers and can provide best practice examples as well as recommendations on how to implement relevant activities. These schools can act as agents of STEAM Education. The school has established systematic collaboration with community stakeholders and other external partners on specific STEAM activities/projects.</i>

These 4 school typologies are used in order to facilitate the school management in their effort to improve the school concerning the level of STEAM approaches integration. It is not to rank the school but to let the management know what activities, interventions and strategies should follow in order to integrate STEAM approaches in their everyday activities. For this reason, the L-STEAM project will develop specific strategies for each one of the school typologies. These will be based in the following characteristics:

- **STEAM for beginners: from initial procedures to holistic action plans (Starter).** Schools that are at an initial stage in relation to STEAM activities, are offered needs-analysis tools that aim to identify areas that are in need for immediate action and modernisation, such as CPD, use of ICT, creation of educational content, participation in communities of peers and others.
- **Introducing STEAM to competent schools: from essential change to acceleration (Enabled).** These schools have strong capacity to innovate, they are implementing local STEAM projects and activities but they are operating in isolation and usually they are missing numerous opportunities to integrate external resources to their plans and programmes.
- **Reinventing schools: forward looking scenarios and future classrooms (Advanced).** The aim of L-STEAM for proposing strategies for schools that have already achieved a high level of STEAM in their operation is twofold. The first one is that we are considering sustainability as a route to the future. The STEAM IDEAS' Square Approach puts emphasis on creating viable change to school settings that lasts and expands. The second reason is that education systems simply must evolve. Three words sum up the change that has to happen: experimentation, independence, and sharing.

- **From innovative schools to STEAM-enriched learning ecosystems (Master).** In this category schools have well established innovation and STEAM plans; they have already introduced a culture of sharing while they have well established cooperation with other schools and with external stakeholders. The NEXT STEP strategy for these schools is to emphasise on the integration of the STEAM and School Innovation culture in the school setting.

### 3.1.2. Civic engagement strategies connected to social stakeholders

L-STEAM will propose civic engagement strategies that aim to connect STEAM Ideas Square with various stakeholders through participatory and targeted actions. A key principle is to understand the interests and needs of each stakeholder to ensure meaningful and sustained involvement.

For **schools**, strategies include co-creating interdisciplinary STEAM projects involving students, teachers, families and other members of the school community that address real-world challenges, fostering a sense of agency and relevance in being part of the solution. Engagement can be strengthened through student-led community performances and exhibitions, teacher training in inclusive pedagogies and open activities that invite public dialogue.

With **public authorities**, engagement focuses on creating spaces for dialogue where educational innovation aligns with and informs local policy. Strategies include joint initiatives on sustainability, digital transition and inclusion, as well as involving authorities in evaluation and dissemination efforts to ensure the impact and scalability of policies.

For **industry and private sector** players, we encourage partnerships through mentoring programmes, STEAM innovation challenges and internships that link education with business and technology development. Co-creating activities that align workforce needs will encourage mutual benefit and long-term collaboration .

**Creative Industry / Art Organisations** are key stakeholders in exchanging both skills and experiences with schools and students. Art collectives, individual artistic, and creative industry companies can be involved throughout knowledge exchange workshops in the STEAM activities, strategic meetings during organizational phases and joint funding applications.

For the **wider community and NGOs**, strategies include involving local organisations in the design and delivery of educational content, using participatory science projects (citizen science, for example, and science through the arts) to promote civic responsibility, and organising public events that encourage dialogue between science, culture and society.

With **media** (newspapers or online news sites, media departments of universities, student journalists, radio stations or podcasts), strategies involve the creation of press releases, feature articles, interviews, projects with the school (for example undergraduate



communication students could do a media project with the school children) to enhance STEAM awareness, increase societal knowledge on STEAM education, and expand outreach with different or new target audiences.

These L-STEAM strategies aim to activate the role of each stakeholder in the societal ecosystem, promoting civic responsibility, mutual learning and the inclusive transformation of society, giving meaning to education and leverage the role of education on the local, national and global landscape.

## 3.2. Examples / Case studies of Competence-Based Learning Activities

The examples presented in this chapter illustrate how competence-based learning can be flexibly implemented through Performing Arts within the STEAM IDEAS' Square framework. These practices are not prescriptive models, but adaptable approaches that can be tailored to various educational contexts, levels, and student needs. They reflect how artistic processes—such as storytelling, music, drama, and movement—can foster critical thinking, collaboration, research, and creativity while engaging learners in interdisciplinary exploration. Grounded in real-world relevance and inclusive participation, the activities are designed to support teachers in cultivating the core STEAM competencies through hands-on, performative, and reflective experiences that bridge formal and informal education<sup>2</sup>.

### The Learning Science Through Theater (<https://lstt.eu/>)

Science View for more than 11 years is realising the Learning Science Through Theater Initiative. This initiative is covering almost all the categories of the competences that the L-STEAM project has identified (see Chapter 2). Also, it could refer to any school typology, this depends on the way that each teacher would like to realise the activity.



In the context of the activity, students **develop and implement a theatrical performance related to scientific concepts and learn science in a creative way**. The specific objectives of the activity, which have as a central axis the **interdisciplinary interconnection of science with aspects of art**, aiming at the enhancement of students' interest in science, involve both students and

teachers. More specifically, through this activity, students comprehend **scientific concepts** and phenomena, develop a spirit of **cooperation and teamwork**, actively participate in the elaboration of scientific concepts and they **develop creative and critical thinking skills**. Also, by participating in dissemination activities and entrepreneurial actions for the promotion and support of their theatrical performance, they contribute in further **bridging school with society** and at personal level developing their **social and entrepreneurial skills**.

<sup>2</sup> An additional repository of practices is here:

<https://www.the-next-step.eu/next-step-scenarios-of-use/>



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**Figure 4:** Photos from the live performances of LSTT in Greece (consent from the students' parents are available)

Teachers will be engaged in **professional development** procedures through their cooperation and the exchange of opinions, ideas and teaching material (either in person or through online learning communities). Finally, one of the main aims of the activity is to motivate more and more teachers and students and create an **educational community** that will cooperate, exchange opinions, material and best practices for science teaching and learning, that will continue after the implementation of the action.

### The formation of Ozone layer

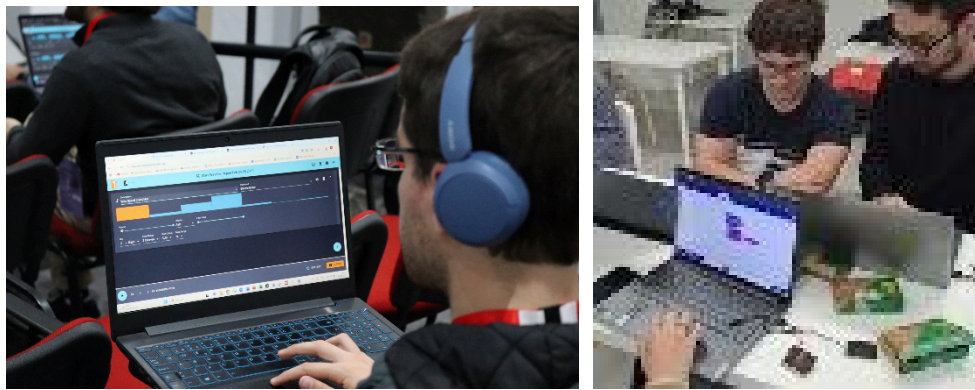
**STEAM School Malta/Tiskopri** (Focus area: 2.1 Creative and Critical Thinking in Performing Arts, 2.2 Interdisciplinary Knowledge Through the Arts, 2.6 Artistic and Creative Expression in STEAM): since 2010 the University of Malta engaged dozens of schools in Malta with science and arts activities through the STEAM School Malta as part of the CREATIONS and STEAM Summer School projects. The sessions engaged students in 20 minutes hands-on science activity, followed by 20 minutes arts activity to reflect and communicate the science learnt (2.1 and 2.2, 2.6). The project demonstrated a statistically significant increase in confidence in science. Some of the activities included a physical game of tag run in an open area used to learn about how the Ozone layer was formed. They learnt the equation, how the Ozone layer forms, and how CFC chemicals destroy the Ozone layer and what humanity did to stop the breakdown. Then the students would perform a short play to dramatise the learnings. They gave shape to the characters and crafted a storyline which they presented in a short 1–3 minutes play.



**Figure 5:** Students practicing “The formation of Ozone layer” scenario (Photo: Edward Duca, Ozone STEAM Activity Tiskopri)

## Music and STEM

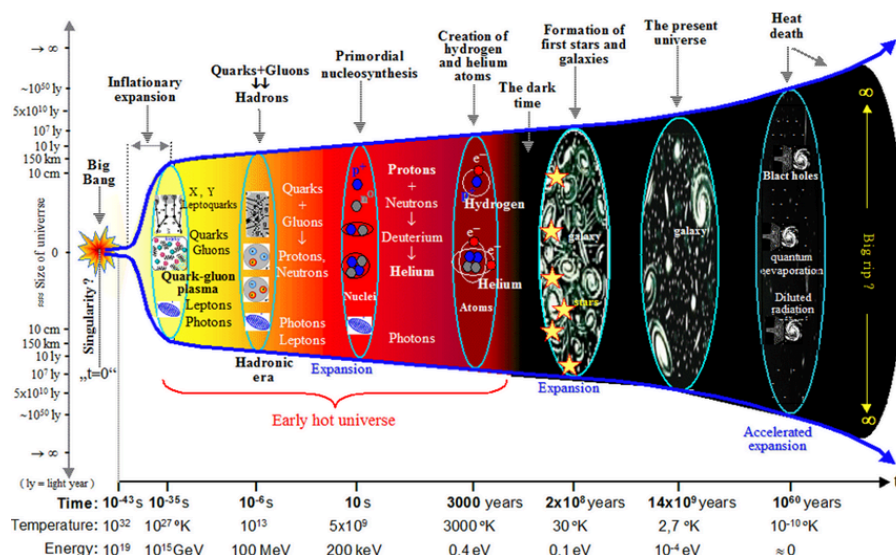
A good practice aligned with L-STEAM pedagogical principles is the Soundscapes Project (ERASMUS+), which invites students to explore their acoustic environment and transform it into creative outputs. In this activity, students record local sounds, analyze them scientifically, and reinterpret them through artistic forms such as music, storytelling, and digital media. This approach promotes Competence 2.2 (Interdisciplinary Knowledge Through the Arts) by linking environmental science, sound physics, and music, as well as Competence 2.6 (Artistic and Creative Expression in STEAM) by fostering creative reinterpretation of environmental data. The project also supports Competence 2.5 (Research and Exploration Skills Through the Arts) through inquiry-based learning and sound analysis. It is particularly suitable for ENABLED and ADVANCED schools, where interdisciplinary teaching and basic ICT integration are already present (NUCLIO photos).



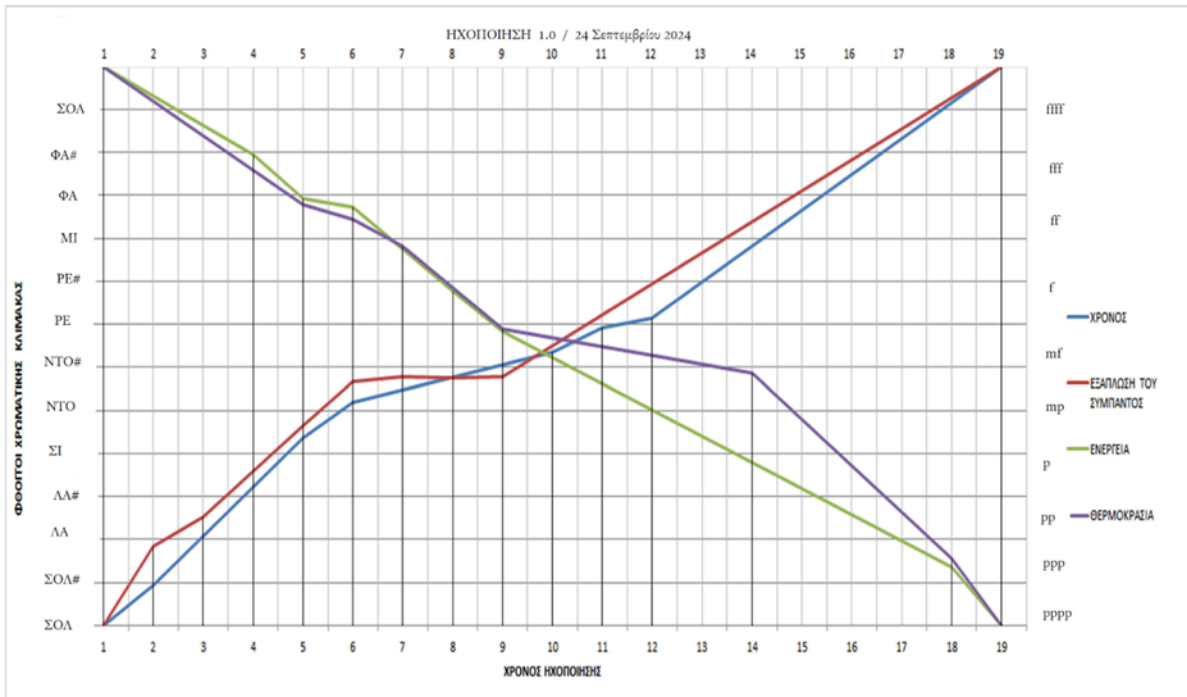
**Figure 6:** Students practicing online sonification modules

### Beginnings, a sonification about the history of the universe

“Beginnings” is a cross-disciplinary educational activity that transforms cosmological data into music through sonification, offering students a creative and scientific exploration of the history of the universe. The project centers around three key cosmological moments: the origin of the universe (“the beginning”), the decoupling of light and matter, and the present day. Using a logarithmic Cartesian graph, students plotted temperature, energy, and expansion data at these three points in time along a timeline represented by the x-axis. The y-axis, corresponding to a 12-note chromatic musical scale, allowed students to convert scientific values into musical notes. The result was a symbolic and auditory representation of the universe’s evolution.

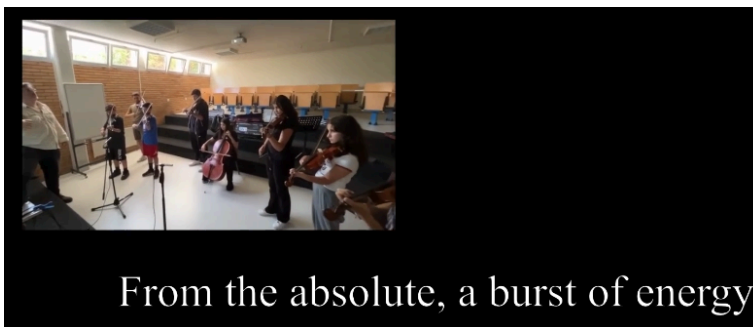


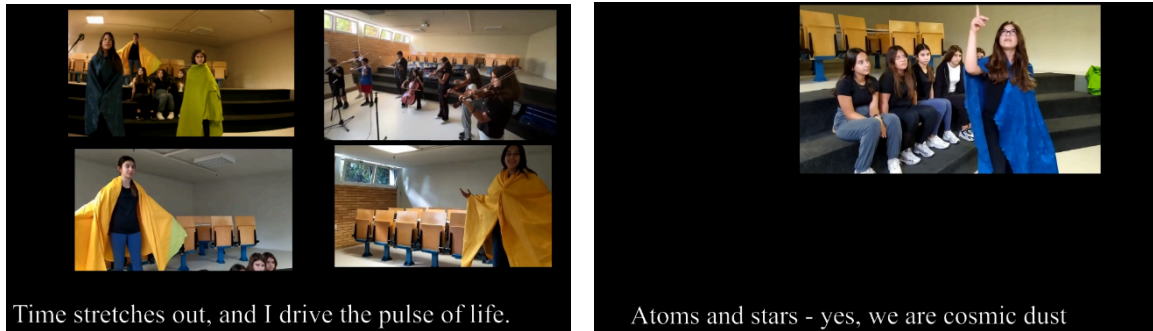
**Figure 7:** The Story of the Universe after the Big Bang



**Figure 8:** *The graphic notation as a result of sonification*

Students then used these plotted data to construct three musical chords, each corresponding to one of the three moments in time. The dynamics of the chords (e.g., Forte, Piano) were mapped using a color-coded system—red, brown, blue, and green—reflecting variations in intensity and tone. A graphic score was derived from the data using Excel and logarithmic reduction methods, supported by AI to generate a twelve-tone scale aligned with both pitch and dynamic values. The final composition was structured over 19 beats (or time steps) on the x-axis, echoing a slow metronome, with the y-axis functioning dually as pitch and dynamic range.





**Figure 9:** Photo excerpts from the GSO 2024 Greek scene (EA)

The activity culminated in a two-minute performance by seven secondary school string students playing violins, violas, and a violoncello. Each student interpreted one of the sonified data points, creating a layered musical experience that encapsulated both scientific precision and artistic expression. A poem, written by the students, complemented the musical composition, adding a narrative and reflective dimension. This good practice illustrates how STEAM (Science, Technology, Engineering, Arts, Mathematics) education can connect abstract scientific phenomena with embodied, performative learning—making complex cosmological concepts both accessible and meaningful through collaborative music-making. The activity involved 1st, 2nd and 3rd grade High School students along with 5th primary school pupils under the guidance of two Music teachers and one Physics teacher.

Students transformed cosmological data into musical expressions, fostering creative and critical thinking (2.2) as they mapped scientific values to pitch and dynamics. The activity promoted interdisciplinary knowledge (2.3) by blending astrophysics, mathematics, and music, while also requiring technological literacy (2.5) through the use of Excel, logarithmic modeling, and AI-supported tools. Collaboration was essential in coordinating a live ensemble performance and co-authoring a poem, cultivating cooperation and communication (2.4). The research-driven process of interpreting data and designing artistic outputs nurtured research and exploration skills (2.6), and the expressive final performance highlighted students' artistic and creative expression (2.7). Through rehearsal, iteration, and live interpretation, the project also cultivated adaptability and resilience (2.8), making abstract scientific phenomena both tangible and emotionally resonant through collaborative performance. This activity may be suitable for ADVANCED and MASTER schools.

### Rubber band guitar for understanding vibration and sound

This hands-on activity, implemented as part of the *Music n STEAM Explorium* program offered by INQUIRIUM, invites children to build a simple guitar using a recycled box and rubber bands of varying thickness and tension. Students pluck the rubber bands and explore how sound is produced through vibration and how pitch changes depending on the tension and thickness of the material. The activity provides an introduction to acoustic principles and wave behaviour, allowing abstract scientific concepts to become accessible through direct experimentation. Given the young age of the students, this serves as an initial exposure to STEAM learning and foundational scientific thinking, laying the groundwork for more

advanced inquiry through creative, playful exploration. We piloted this activity with lower primary school students (6 years old), introducing them to concepts like ‘vibration’ and asking them to identify pitch differences through playful investigation. It builds on earlier activities in the program—such as ‘Can you feel the sound?’ and the ‘Water xylophone’, which introduces foundational ideas of sound transmission and pitch variation using the senses of touch and hearing. For older students (ages 9–12), the activity can be expanded to include more advanced scientific exploration. Learners can measure string length and tension, investigate the relationship between pitch and wavelength, and visualise sound waves using digital applications or smartphone oscilloscopes. As an additional challenge, students can design more refined string instruments incorporating resonance boxes or using 3D printers and then test how different materials affect sound quality and amplification. This activity aligns with competence 2.2 (interdisciplinary knowledge through the arts), as it blends elements of physics, music, and basic engineering, and with 2.5 (research and exploration skills through the arts), as it promotes hands-on inquiry and experimentation. It is especially suitable for ENABLED schools that support collaborative, cross-disciplinary STEAM learning.



**Figure 10:** Pupils practicing “Rubber band guitar for understanding vibration and sound”

## 4. Impact Assessment of the L-STEAM Approach

The impact assessment of the L-STEAM approach focuses on evaluating the short-, medium-, and long-term effects of the project on its target groups and stakeholders. It aims to measure the extent to which the project contributes to fostering interdisciplinary learning, creative expression, and inclusive participation in STEAM education across diverse communities. The assessment will capture both intended and emerging impacts at individual, institutional, and systemic levels, using already identified qualitative and quantitative indicators (WP1). Special attention will be given to how the L-STEAM methodology influences teachers' and students' competencies, educators' practices, local partnerships, and the broader cultural and educational landscape.

### 4.1. Impact assessment of Implementation and Training Activities

L-STEAM's local and regional activities, including focus groups, training sessions, student-led actions, and pilot initiatives, will be assessed to ensure their quality, inclusiveness, and alignment with the project's educational and cultural goals. Assessment will consider the level of engagement of participants, the appropriateness of methodologies used, and the degree to which these activities contribute to building local capacities in STEAM. Observations, participant feedback, and self-assessment tools will support this process.

The **assessment of the implementation activities (interventions in schools)** will consist of:

1. **Assessment of the Impact from the school unit through the self-reflection tool of the project.** The project will use the NEXT-STEP Self Reflection tool in order to measure the impact of STEAM in the school unit and how the level of integrating STEAM activities is improved. The Self Reflection tool will be presented in Activity 4.5.
2. **Assessment of the teachers participating in the activities** with pre and post questionnaires as well as self-reflection forms. The questionnaires will be presented in Activity 4.5.
3. **Evaluation from the students participating in the activities** through pre and post questionnaires. The questionnaires will be presented in Activity 4.5.

The **evaluation of the Training activities**, the Summer Schools, that will be provided to teachers for their professional development, will be conducted through specific questionnaires as well as focus groups (interviews) during the 2 summer schools of the project.

## 5. Conclusion

### 5.1. The Future of STEAM Competencies in Education

STEAM competencies in education are very widespread across Europe and are implemented in many different ways. First, it is clear that transdisciplinary learning thrives when educators, institutions, and cultural actors collaborate beyond the silos of traditional subjects. Second, the integration of Arts—particularly through performing arts—is a catalyst for deeper student engagement, emotional expression, and conceptual understanding, especially in complex STEM topics.

The L-STEAM approach helps the implementation of STEAM education through the performing arts by offering a structured yet flexible model that provides schools a model for embedding STEAM within educational systems. By situating scientific inquiry within the expressive and narrative-rich frameworks of community engagement, policy making, entrepreneurship the performing arts, and storytelling, L-STEAM not only enhances creativity and communication skills but also fosters empathy, collaboration, and creative and critical thinking. This approach represents a meaningful shift toward a more inclusive, embodied, and culturally responsive vision of STEAM education—one that equips learners not only with knowledge, but with the competencies needed to navigate an increasingly complex world.

In order to integrate and embed this approach in educational systems around Europe more empirical evidence is needed on which STEAM approaches are the most effective (especially when using the performing arts), the development of more resources for teachers (although many toolkits and educational packages already exist), and policy makers, educators and other stakeholders need to work hand in hand to see how to embed the performing arts to teach, inspire and motivate students in STEAM subjects within educational systems around Europe.

### 5.2. Next Steps for Research and Policy

As the integration of performing arts within STEAM education continues to demonstrate its transformative potential, future research must focus on systematically evaluating how embodied, expressive, and narrative-based methods impact students' competence growth across cognitive, interpersonal, and intrapersonal domains. This research should inform a new generation of evidence-based policies that recognize the value of performance as a legitimate and powerful mode of scientific inquiry and learning. By documenting and scaling successful practices like those in the L-STEAM framework, policymakers across Europe can foster educational systems that are not only interdisciplinary but also inclusive, emotionally resonant, and culturally relevant. In this way, research becomes a driving force for policy innovation—shaping curricula, teacher training, and institutional priorities that place the arts at the heart of a reimagined STEAM pedagogy.

## 6. References

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